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THE

FIELD ENGINEER:

A

Handy Book of Practice

IN THE

SURVEY, LOCATION, AND TRACK-WORK OF
RAILROADS;

CONTAINING

A LARGE COLLECTION OF RULES AND TABLES,

ORIGINAL AND SELECTED,

APPLICABLE TO BOTH THE STANDARD AND THE
NARROW GAUGE,

AND PREPARED WITH SPECIAL REFERENCE TO
THE WANTS OF

THE YOUNG ENGINEER.

BY

WILLIAM FINDLAY SHUNK, C.E.

NINTH EDITION, REVISED AND ENLARGED.

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THE AUTHOR

Affectionately Dedicates this Book

TO

ALBERT J. SCHERZER, C.E.,

Old Comrade and Dear Friend,

IN TOKEN OF ESTEEM FOR HIS PROFESSIONAL
ATTAINMENTS AND RESPECT FOR HIS
MANLY CHARACTER.

32X121

own practice having been unusually large and diversified, probably the examples given will prove adequate, directly or indirectly, to all contingencies.

No attempt has been made to swell the bulk of the volume with imaginary cases; the object being, not to provide barren mathematical exercises, but to teach useful knowledge.

Problems, also, affecting location in its economical aspects, — the balancing of physical and financial conditions, equating of alternative lines, and the like, — do not come within the scope of the work, and are therefore not treated.

Considerable pains have been spent on the tables. However far the young engineer may eventually outgo his teacher as regards the text of the book, these are implements of his art which never become antiquated, and can never fall into disuse. Those herein contained which are original will, it is hoped, be esteemed worthy of place with their well-approved associates.

The author invites friendly criticism: he would be pleased to receive suggestions, both for the improvement of the book, and for the correction of possible errors in it, should another edition be called for.

In dismissing the work from his hands, the precarious snatches of time occupied in its preparation, by day and by night, during the past two years, which might have been more agreeably spent in reading, talking, or musing, recur to the writer's mind; and the thought arises, To what end or from what motive do people undertake these technical labors? Why should Forney and Bourne toil to simplify steam for our apprehension; Nystrom to compile mechanical, Molesworth and Trautwine to epitomize civil engineering; Henck to prepare his elegant manual of field mathematics; Box to illustrate hydraulics; and Shreve, with lucid pen, to make clear for us the strains in truss or arch? The ordinary motives to en-
vor here have no place. There is neither fame nor profit
ese drudging enterprises. At best the author gives name

to his book; he remains impersonal, — known but indirectly, and but to a class. How, then, shall we account for his labors? I take it, the Father of mankind has not only made our minds to hunger for knowledge as our bodies for food, but has also imposed upon us a kindly law of communion, by virtue whereof we cannot do otherwise, without violence to generous nature, than share with our fellows whatsoever we have learned that seems new and useful. Under this law these beneficial works would appear to have had their being, and thus pure are they from the stain of selfishness.

Though the present writer would not arrogate equal fellowship in the eminent brotherhood named, yet he may justly claim like pureness from unworthy motive, and certainly feels like comfort at heart to that which they must know, for having discharged, in what measure it has been laid upon him, the divine obligation.

WM. F. SHUNK.

RAHWAY, N.J.

PREFACE TO THE NINTH EDITION.

ALTHOUGH the writer has thanked individually all who have sent him *errata* from time to time, he cannot regard this enlarged edition of the "FIELD ENGINEER" as complete without a general salutation to them. Thanks, too, for pleasing evidences, received from many hands, that the book has been helpful to those for whom it was intended.

He would make special acknowledgment to Mr. T. C. Mendenhall, Supt. U. S. Coast and Geodetic Survey, and to his assistant, Mr. C. A. Schott, for the new astronomical tables herein first printed, which were kindly computed for this edition in response to a call for much less.

He would also express his obligation to Mr. Fred. Brooks, C.E., Boston, Mass., whose critical suggestions for the betterment of the text have in the main been adopted.

These gentlemen are strangers to their beneficiary. He as outcropping ledge, water-table of building, or other permanent object. Usually a blunt conical seat for the rod, hewn on a buttressed tree-base, having a small nail sometimes driven flush in the top of it, and a blaze opposite, on which the elevation is marked with kiel.

T. P. *Turning-point:* usually marked ⊙ in the field-book.

P. I. *Point of intersection:* as of tangents, which are to be connected by a curve.

A. D. *Apex distance:* i.e., the distance from the P. I. to the point where a curve merges in the tangent.

P. C. *Point of curve:* the stake-mark at the beginning of a curve.

P. T. *Point of tangent:* the stake-mark at the end of a curve.

P. C. C. *Point of compound curvature:* the stake-mark where a curve merges in another of different curvature, turning in the same direction.

P. R. C. *Point of reverse curvature:* the stake-mark where a curve merges in another turning in the opposite direction.

B. S. *Backsight,* in transit work; or the reading of the rod to ascertain the instrument height in levelling.

F. S. *Foresight,* in transit work; or the reading of the rod to ascertain elevations in levelling.

H. I. *Height of instrument:* elevation of the level above the *datum* or *zero plane.*

H. W. *High water.*

L. W. *Low water.*

LOGARITHMS.

I.—II.

LOGARITHMS.

I.

DEFINITIONS AND PRINCIPLES.

1. The logarithm of a number is the exponent of the power to which it is necessary to raise a fixed number to produce the given number; that is to say, it represents the number of times a fixed number must be multiplied by itself in order to produce any given number.

The fixed number is called the *base of the system.* In the common system, this base is 10.

It follows from the above, that the logarithm of any power of 10 is equal to the exponent of that power. If, therefore, a number is an exact power of 10, its logarithm is a whole number.

If a number is not an exact power of 10, its logarithm will not be a whole number, but will be made up of an *entire part* plus a *fractional part,* which is generally expressed decimally. The entire part of the logarithm is called the *characteristic;* the decimal part is called the *mantissa.*

2. The characteristic of the logarithm of a whole number is positive, and numerically 1 less than the number of places of figures in the given number.

Thus, if a number lies between 1 and 10, its logarithm lies between 0 and 1; that is, it is equal to 0 *plus* a decimal. If a number lies between 10 and 100, its logarithm is equal to 1 *plus* a decimal; and so on.

3. The characteristic of the logarithm of a decimal fraction is negative, and numerically 1 greater than the number of 0's that immediately follow the decimal point.

The characteristic alone, in this case, is negative, the mantissa being always positive. This is indicated by writing the negative sign over the characteristic: thus, $\bar{2}.380211$ is equivalent to $-2 + .380211$. (See last example, p. 8.)

4. The characteristic of the logarithm of a mixed number is the same as that of its entire part. Thus the mixed number 74.103 lies between 10 and 100; hence its logarithm lies between 1 and 2, as does the logarithm of 74.

5. The logarithm of the product of two numbers is equal to the sum of the logarithms of the numbers.

The logarithm of a quotient is equal to the logarithm of the dividend diminished by that of the divisor.

The logarithm of any power of a number is equal to the logarithm of the number multiplied by the exponent of the power.

The logarithm of any root of a number is equal to the logarithm of the number divided by the index of the root.

6. The preceding principles enable us to abridge labor in arithmetical calculations, by using simple addition and subtraction instead of multiplication and division.

II.

MANNER OF USING THE TABLES.

TO FIND THE LOGARITHM OF ANY NUMBER.

1. First find the characteristic by rule 2, 3, or 4, given above.

2. Then, if the number be less than 100, look in column N of the table for 10 times or 100 times the amount of it; opposite this multiple, in column O, will be found the mantissa.

Thus the logarithm of 6 is 0.778151; that of 84 is 1.924279.

3. If the number lie between 100 and 10000, find the first three figures of it in column N; then pass along a horizontal line until you come to the column headed with the fourth figure of the number. At this place will be found the mantissa.

Thus the logarithm of 7200 is 3.857332; that of 8536 is *3.931254.*

4. If the number be greater than 10000, place a decimal point after the fourth figure, thus converting the number into a mixed number. Find the mantissa of the entire part by the method last given. Then take from column D the corresponding *tabular difference*, multiply this by the decimal part, and add the product to the mantissa just found. The principle employed is that the differences of numbers are proportional to the differences of their logarithms, when these differences are small.

Thus the logarithm of 672887 is 5.827943; that of 43467 is 4.638160.

5. If the number be a decimal, drop the decimal point, thus reducing it to a whole number. Find the mantissa of the logarithm of this number, and it will be the mantissa required.

Thus the logarithm of .0327 is $\bar{2}$.514548; that of 378.024 is 2.577520.

TO FIND THE NUMBER CORRESPONDING TO A GIVEN LOGARITHM.

6. The rule is the reverse of those just given. Look in the table for the mantissa of the given logarithm. If it cannot be found, take out the next less mantissa, and also the corresponding number, which set aside. Find the difference between the mantissa taken out and that of the given logarithm; annex as many 0's as may be necessary, and divide this result by the corresponding number in column D. Annex the quotient to the number set aside, and then point off from the left hand a number of places of figures equal to the characteristic plus 1; the result will be the number required. If the characteristic is negative, the result will be a pure decimal, and the number of 0's which immediately follow the decimal point will be one less than the number of units in the characteristic.

Thus the number corresponding to the logarithm 5.233568 is 171225.296; that corresponding to the logarithm $\bar{2}$.233568 is .0171225.

MULTIPLICATION BY MEANS OF LOGARITHMS.

7. Find the logarithms of the factors, and take their sum; then find the number corresponding to the resulting logarithm, and it will be the product required.

Example.

Find the continued product of 3.902, 597.16, and 0.0314728.

Operation.

Log. 3.902 . . . 0.591287
Log. 597.16 . . . 2.776091
Log. 0.0314728 . $\bar{2}.497936$
1.865314 = log. 73.3354, the product.

Here the $\bar{2}$ cancels the + 2, and the 1 carried from the decimal part is set down.

DIVISION BY MEANS OF LOGARITHMS.

8. Find the logarithms of the dividend and the divisor, and subtract the latter from the former; then find the number corresponding to the resulting logarithm, and it will be the quotient required.

Example 1.

Divide 24163 by 4567.

Operation.

Log. 24163 . . . 4.383151
Log. 4567 . . . 3.659631
0.723520 = log. 5.29078, the quotient.

Example 2.

Divide 0.7438 by 12.9476.

Operation.

Log. 0.7438 . . . $\bar{1}.871456$
Log. 12.9476 . . . 1.112189
$\bar{2}.759267$ = log. 0.057447, the quotient.

Here 1 taken from - gives $\bar{2}$ for a result. The subtraction, as in this case, is always to be performed in the algebraic way.

9. The operation of division, particularly when combined with that of multiplication, can often be simplified by using *the principle of the* arithmetical complement.

The arithmetical complement of a logarithm (written a. c.)

is the result obtained by subtracting it from 10: it may be written out by commencing at the left hand, and subtracting each figure from 9 until the last significant figure is reached, which must be taken from 10. Thus 8.130456 is the arithmetical complement of 1.869544.

To divide one number by another by means of the arithmetical complement, find the logarithm of the dividend and the arithmetical complement of the logarithm of the divisor; add them together, and diminish the sum by 10; the number corresponding to the resulting logarithm will be the quotient required.

Example.

Multiply 358884 by 5672, and divide the product by 89721.

Operation.

	Log. 358884 . . .	5.554954
	Log. 5672 . . .	3.753736
(a.c.)	Log. 89721 . . .	5.047106
		4.355796 = log. 22688, the result.

The operation of subtracting 10 is performed mentally.

TO RAISE A NUMBER TO ANY POWER BY MEANS OF LOGARITHMS.

10. Find the logarithm of the number, and multiply it by the exponent of the power; then find the number corresponding to the resulting logarithm, and it will be the power required.

Example.

Find the 5th power of 9.

Operation.

Log. 9	0.954243
	5
	4.771215 = log. 59049, the power.

TO EXTRACT ROOTS BY MEANS OF LOGARITHMS.

11. Find the logarithm of the number, and divide it by the index of the root; then find the number corresponding to the resulting logarithm, and it will be the root required.

Example.

Find the cube root of 4,096.

Operation.

Log. 4,096, 3.612360; one-third of this is 1.204120, to which the corresponding number is 16, which is the root sought.

12. When the characteristic is negative, and not divisible by the index, add to it the smallest negative number that will make it divisible, and then prefix the same number, with a plus sign, to the mantissa.

Example.

Find the 4th root of .00000081. The logarithm of this number is $\bar{7}.908485$, which is equal to $\bar{8} + 1\ 908485$, and one-fourth of this is $\bar{2}.477121$; the number corresponding to this logarithm is .03: hence .03 is the root required.

13. Five-figure logarithms are sufficiently accurate for ordinary railroad field-work. The tables in this book may therefore, as a rule, be used without interpolation.

PLANE TRIGONOMETRY.

III.—VIII.

PLANE TRIGONOMETRY.

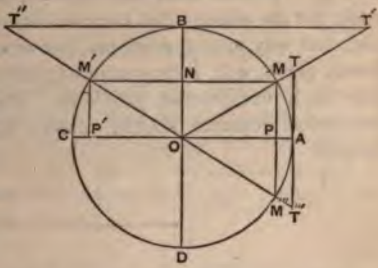
III.

DEFINITIONS.

1. Plane Trigonometry treats of the solution of plane triangles.

In every plane triangle there are six parts, — three sides and three angles. When three of these parts are given, one being a side, the remaining parts may be found by computation. The operation of finding the unknown parts is called the solution of the triangle.

2. A plane angle is measured by the arc of a circle included between its sides; the centre of the circle being at the vertex, and its radius being 1. The circle, for convenience, is divided into 360 equal parts called degrees; 90 of these parts are included in a quadrant, which includes one-quarter of the circle, and is the measure of a right angle. Each degree is further divided into 60 equal parts called minutes, and each minute into 60 equal parts called seconds. Degrees, minutes, and seconds are denoted by the symbols °, ′, ″: thus the expression 7° 22′ 33″ is read, 7 degrees, 22 minutes, and 33 seconds.



3. The complement of an angle is the difference between that angle and a right angle.

4. The supplement of an angle is the difference between that angle and two right angles.

5. Instead of employing the arcs themselves, certain functions of the arcs are usually employed, as explained below. A function of a quantity is something which depends upon that quantity for its value.

The *sine* of an angle is the distance from one extremity of the arc enclosing it, to the diameter, through the other extremity. Thus P M is the sine of the angle M O A.

The *cosine* of an angle is the sine of the complement of the angle. Thus N M = O P is the cosine of the angle M O A.

The *tangent* of an angle is a right line which touches the enclosing arc at one extremity, and is limited by a right line drawn from the centre of the circle through the other extremity: the sloping line which thus limits the tangent is called the *secant* of the angle. A T is the tangent and O T the secant of the angle M O A.

The *versed sine* of an angle is that part of the diameter A P which is intercepted between the foot of the sine and the extremity of the enclosing arc.

The *cotangent* of an angle is the tangent of the complement *of that angle*: the *co-versed* sine and cosecant are similarly *defined.* Thus B T′, B N, and O T′ are respectively the *cotangent, co-versed sine*, and cosecant of the angle M O A.

These terms are in practice indicated by obvious contractions; as, *sin.* A for the sine of A, *cos.* A for the cosine of A, &c.

6. The above definitions have been made with reference to a radius of 1. Any function of an arc whose radius is R is equal to the corresponding function of an arc whose radius is 1, multiplied by the radius R. So also any function of an arc whose radius is 1 is equal to the corresponding function of an arc whose radius is R, divided by that radius.

7. Arcs greater than half a circle are not treated in this book, for the reasons that they seldom occur in field practice, and that any young engineer, conversant with the methods herein given, will, it is presumed, have no difficulty in handling such exceptional problems. Those curious in trigonometrical research should consult special treatises on the subject.

IV.

NATURAL SINES, ETC.

1. Natural sines, cosines, tangents, or cotangents are those which are referred to a radius of 1. They may be used for all the purposes of trigonometrical computation; but it is found more convenient, in many cases, to employ a table of logarithmic functions.

V.

LOGARITHMIC SINES, ETC.

1. Logarithmic functions are the logarithms of the natural functions treated in foregoing Art. IV., the characteristics throughout being transformed by the algebraic addition of 10, *which has the effect* of referring the tabular functions to a *radius of 10,000,000,000* instead of unity, and of thus, it is sup-

posed, simplifying computation. For the intelligent use of these tables, however, it should be remembered that the characteristic 9 indicates a negative characteristic − 1, being one less than 10; a characteristic 7 indicates a negative characteristic − 3, and so on. Hence, in figuring with these logarithms, as many tens must be subtracted from the final result as have been added in the operation. This rule is illustrated in the following examples.

TO FIND THE LOGARITHMIC FUNCTIONS OF AN ARC WHICH IS EXPRESSED IN DEGREES AND MINUTES.

2. If the arc is less than 45°, look for the degrees at the top of the page, and for the minutes in the left-hand column; then follow the corresponding horizontal line till you come to the column designated at the top by *sine*, *cosine*, *tang.*, or *cotang.*, as the case may be; the number there found is the logarithm sought.

Thus, log. sin. 19° 55′ 9.532312
log. tang. 19° 55′ 9.559097

3. If the angle is greater than 45°, look for the degrees at the bottom of the page, and for the minutes in the right-hand column; then follow the corresponding line towards the left, till you come to the column designated at the *bottom* by *sine*, *cosine*, *tang*, or *cotang*, as the case may be; the number there found is the logarithm sought.

Thus, log. cos. 52° 18′ 9.786416
log. tan. 52° 18′ 10.111884

4. If the arc is expressed in degrees, minutes, and seconds, proceed as before with the degrees and minutes; then multiply the corresponding number taken from column D by the number of seconds, and add the product to the preceding result, for the sine or tangent, and subtract it therefrom for the cosine or cotangent.

Example.

Find the logarithmic sine of 40° 26′ 28″.

Operation.

Log. sine 40° 26′ 9.811952
Tabular diff. 2.47
No. of seconds, 28
Product . 69.16 to be added . 69
Log. sine 40° 26′ 28″ 9.812021

5. If the arc is greater than 90°, find the required function of its supplement. Thus the logarithmic tangent of 118° 18′ 25″, is equivalent to that of its supplement, or 61° 41′ 35″, and is 10.268732. Also the logarithmic cosine of 95° 18′ 24″ is 8.966078, and the log. cot. of 125° 23′ 50″ is 9.867579.

TO FIND THE ARC CORRESPONDING TO ANY LOGARITHMIC FUNCTION.

6. This is done by a reverse process. Look in the proper column of the table for the given logarithm; if it is found there, the degrees are to be taken from the top or bottom, and the minutes from the left or right hand column, as the case may be. If the given logarithm is not found in the table, find the next less logarithm, take from the table the corresponding degrees and minutes, and set them aside. Subtract the logarithm found in the table from the given logarithm, and divide the remainder by the corresponding tabular difference. The quotient will be seconds, which must be *added* to the degrees and minutes set aside, in the case of a sine or tangent, and *subtracted* in the case of a cosine or cotangent.

Example.

Find the arc corresponding to log. sin. 9.422248.

Operation.

Given logarithm . . . 9.422248
Next less in table . . . 9.421857 . . . .15° 19′.
Tabular diff. . . 7.68) 391(51″ to be added.

Hence the required arc is 15° 19′ 51″.

7. By analogous process, the arc corresponding to log. cos. 9.427485 will be found to be 74° 28′ 43″.

VI.

GENERAL PROPOSITIONS.

1. *In any right-angled triangle* the hypothenuse is to one of the legs as the radius to the sine of the angle opposite to that leg.

And one of the legs is to the other as the radius to the tangent of the angle opposite to the latter.

2. *In any plane triangle,* as one of the sides is to another, so is the sine of the angle opposite to the former to the sine of the angle opposite to the latter.

3. *In any plane triangle,* as the sum of the sides about the vertical angle is to their difference, so is the tangent of half the sum of the angles at the base to the tangent of half their difference.

4. *In any plane triangle,* as the cosine of half the difference of the angles at the base is to the cosine of half their sum, so is the sum of the sides about the vertical angle to the third side, or base.

Also, as the sine of half the difference of the angles at the base is to the sine of half their sum, so is the difference of the sides about the vertical angle to the third side, or base.

5. *In any plane triangle,* as the base is to the sum of the other two sides, so is the difference of those sides to the difference of the segments of the base made by a perpendicular let fall from the vertical angle.

6. *In any plane triangle,* as twice the rectangle under any two sides is to the difference of the sum of the squares of those two sides and the square of the base, so is the radius to the cosine of the angle contained by the two sides.

VII.

SOLUTION OF PLANE TRIANGLES.

1. It is usually, though not always, best to work the proportions in trigonometry by means of logarithms, taking the logarithm of the first term from the *sum* of the logarithms of the second and third terms, to obtain the logarithm of the fourth term; or adding the arithmetical complement of the logarithm of the first term to the logarithms of the other two, to obtain that of the fourth.

2. There are three distinct cases in which separate rules are required.

CASE I.

3. When a side and an angle are two of the given parts, the solution may be effected by proposition 2 of the preceding section.

If a *side* be required, say, —

As the sine of the given angle is to its opposite side,

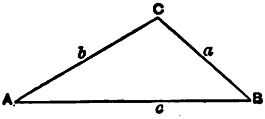
So is the sine of either of the other angles to its opposite side.

4. If an *angle* be required, say, —

As one of the given sides is to the sine of its opposite angle,

So is the other given side to the sine of its opposite angle.

The third angle becomes known by taking the sum of the two former from 180°.



Example 1.

Given angle $A = 24° 26'$; angle $B = 36° 43'$; side $b = 137.6$: to find side a.

As sin. B . . log. 9.776598
Is to sin. A . log. 9.616616
So is b . . . log. 2.138618
11.755234, sum of 2d and 3d terms,
To a, 95.2 . . log. 1.978636 less 1st term.

Example 2.

Given, sides a and b, as above, and angle A; to find angle B.

As side a . . . . (a. c.)	log.	8.021364	
Is to sin. A	log.	9.616616	
So is side b	log.	2.138618	
To sin. B = 36° 43′	log.	9.776598	sum.

CASE II.

5. When two sides and the included angle are given, the solution may be effected by means of propositions 3 and 4. Thus, take the given angle from 180°; the remainder will be the sum of the other two angles.

Then, by proposition 3, —

As the sum of the given sides is to their difference,

So is the tangent of half the sum of the remaining angles to the tangent of half their difference.

Half the sum of the remaining angles added to half their difference will give the larger of them, and half their sum diminished by half their difference will give the lesser of them.

The solution may be completed either by proposition 4, or by proposition 2, as in Case I.

Example.

Given side $a = 95.2$, side $b = 137.6$, and the included angle c = 118° 51′; to find the remaining angles. Here 180.00 — 118° 51′ = 61° 09′, the sum of the remaining angles.

As sum of given sides, 232.8	log.	2.366983
Is to their difference, 42.4	log.	1.627366
So is *tang.* ½ sum of rem. angles, 30° 34½′ .	log.	9.771447
To *tang.* ½ their difference = 6° 08½′ . . .	log.	9.031830

Adding half the difference to half the sum, 30° 34½′ + 6° 08½′ = 36° 43′, = the larger angle, B. Deducting half the difference from half the sum = 24° 26′ = the smaller angle, A.

This case is susceptible of solution also by means of proposition 6.

CASE III.

6. When the three sides of a plane triangle are given, to find the angles.

First Method.

Assume the longest of the three sides as base; then say, conformably with proposition 5, —

As the base is to the sum of the two other sides,

So is the difference of those sides to the difference of the segments of the base.

Half the base added to half the said difference gives the greater segment, and diminished by it gives the less; thus, by means of the perpendicular from the vertical angle, the original triangle is divided into two, each of which falls under the first case. Or they may be solved by the simpler methods applicable to right-angled triangles.

Second Method.

7. Find any one of the angles by means of proposition 6, and the remaining angles either by a repetition of the same rule, or by the relation of sides to the sines of their opposite angles.

VIII.

RIGHT-ANGLED PLANE TRIANGLES.

1. Right angles may be solved by the rules applicable to all plane triangles; and it will be found, since a right angle is always one of the data, that the rule usually becomes simplified in its application.

2. When two of the sides are given, the third may be found by means of the rule that the square of the hypothenuse is equal to the sum of the squares of the remaining sides.

3. Another method for solving right-angled triangles is as follows: —

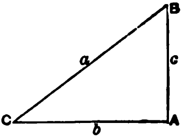
To find a side. Call any one of the sides radius, and write *upon it the word "radius."* Observe whether the other sides become sines, tangents, cosines, or the like, and write upon them the proper designations accordingly. Then say,

As the *name* of the given side is to the given side,
So is the *name* of the required side to the required side.

4. To find an angle. Assume one side to be radius, and mark the remaining sides as before. Then say,

As the side made radius is to radius,
So is the other given side to the *name* of that side;
Which determines the opposite angle.

5. Applying this method to the right-angled triangle A B C, and calling the hypothenuse *a* radius, we shall have,



$$c = a\ sin.\ C \div R;\ \text{hence}\ sin.\ C = Rc \div a.$$
$$b = a\ cos.\ C \div R;\ \text{hence}\ cos.\ C = Rb \div a.$$

Then, assuming the side b to be radius, we shall have,

$$c = b\ tang.\ C \div R;\ \text{hence}\ tang.\ C = Rc \div b.$$

If radius be called 1, the natural sines and cosines will be used in the application of these formulas; they are often more convenient than logarithms in railroad practice, especially when the numbers which measure the sides of the triangle are either less than 12, or are resolvable into factors less than 12.

6. The simpler relations between these natural functions are as follows:

$$sin.^2 + cos.^2 = 1;\ tang. = \frac{sin.}{cos.};\ cotang. = \frac{cos.}{sin.} = \frac{1}{tang.};$$

$$sec. = \frac{1}{cos.};\ cosec. = \frac{1}{sin.};\ versine = 1 - cos.;\ co\text{-}versine = 1 - sin.$$

ADJUSTMENT AND USE
OF
INSTRUMENTS.

IX.–XV.

ADJUSTMENT AND USE

OF

INSTRUMENTS.

IX.

GENERAL REMARKS ON ADJUSTMENTS.

1. Care should be taken in all instrumental adjustments, where screws work in pairs, to loosen one before tightening its opposite.

2. Remember that the eye-piece inverts the image of the cross-hairs, and that consequently any movement of it, by means of the small capstan head screws on the outside of the telescope-barrel, should be in the direction which would seem to increase the error requiring correction.

3. Before beginning the adjustments, screw the object-glass close home, and make a pin-scratch across its rim and the end of the tube, by which to mark its proper place; draw out the eye-piece until the cross-hairs are exactly in focus; that is to say, until no movement of the eye shall appear to displace them, and bring the object to be observed clearly into view.

4. Never permit the glasses to be rubbed with a gritty fabric. To remove the dust from them, use a soft, clean handkerchief, and change often the part applied.

X.

THE LEVEL.

TO BRING THE INTERSECTION OF THE CROSS-HAIRS INTO THE OPTICAL AXIS OF THE TELESCOPE.

1. Set the instrument firmly, cast loose the wyes, and, by levelling and tangent screws, bring either of the cross-hairs to coincide with a well-defined object, distant from 400 to 600 feet, or as much farther as distinct vision can be had free from heat ripple. Gently rotate the telescope half-way around in the wyes. If the cross-hair selected for treatment then fails to coincide with the object, reduce the error one-half by means of the small capstan head screws at right angles to it on the telescope-barrel. Bring the spider-line again to coincide with the object by means of the levelling and tangent screws, and, if necessary, repeat the operation. Proceed in the same manner with the other cross-hair. If the error is large, bring both nearly right before undertaking their final adjustment.

2. Having thus adjusted the line of collimation upon a distant point, requiring the object-tube to be drawn well in, select a point close by, which shall require it to be thrust out almost to its limit. If any error appears, correct half of it with the small screws provided for the purpose, a little forward of the diaphragm, and usually protected by a movable sleeve on the outside; correct the other half with the levelling-screws. After completing this adjustment, test the former one on a distant object, and, if necessary, repeat the operations.

3. In the transit, the small guide-ring screws used for this adjustment are covered by the bulb of the cross-bar in which the telescope is fixed, and are therefore inaccessible. The adjustment, however, is one not liable to become deranged in either instrument, and, in the transit, is of comparatively small importance.

4. The young practitioner should bear in mind that the intersection of the cross-hairs may coincide with the optical axis of the telescope, and yet be out of centre as regards the *field of view*. Such eccentricity does not affect the working *accuracy of the* instrument, which depends upon the position

of the object-piece solely. It may be removed by manipulation of the small screws securing the inner end of the eye-piece.

TO BRING THE LEVEL BUBBLE PARALLEL WITH THE TELESCOPE AXIS.

5. Clamp the instrument over either pair of levelling screws, and bring the bubble to the middle of its tube. Turn the telescope slightly on its bearings, so that the bubble-case shall project a little on one side or the other. If the bubble slips, correct half its movement by means of the small lateral capstan head screws at one end of the case. Return the telescope to its first position, level up again, and repeat the operation until the erroneous movement ceases. This adjustment brings the telescope and level into the same vertical plane.

6. Next, the bubble being at the middle of its tube, carefully lift the telescope out of the wyes, turn it end for end, and replace it. If the bubble settles away from the middle, bring it half-way back by means of the capstan-heads, working up and down at one end of the case. Again middle it with the levelling screws, and repeat the operation until the error is corrected.

TO ADJUST THE WYES; OR, IN OTHER WORDS, TO BRING THE TELESCOPE INTO A POSITION AT RIGHT ANGLES TO THE VERTICAL AXIS OF THE INSTRUMENT.

7. Close the wyes. Unclamp. Set the telescope directly over two of the levelling screws, and with them bring the bubble to the middle of the tube. Then rotate the telescope horizontally, until it stands over the same pair of screws, changed end for end. If the bubble errs, correct one-half of the deviation with the capstan head nuts at the end of the bar, and one-half with the levelling screws. Place the telescope over the other pair of levelling screws. Repeat the operation there; and continue the corrections, over one and the other pair of levelling screws alternately, until the bubble stands without varying during an entire revolution of the instrument upon its vertical axis.

8. The capstan head nuts on the cross-bar should be moved by gradual stress, not by pounding. They are a rude device. With so short a leverage as the length of the common adjusting-pin supplies, it is almost impossible to give them a smooth,

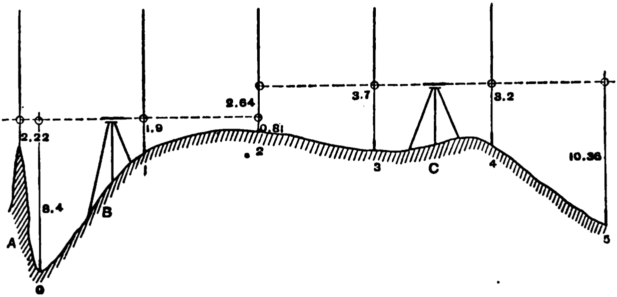
manageable motion. They reproach the instrument-maker's art as unchecked hydrophobia and cancer do that of medicine, or mercenary villany that of law, and should be supplanted by better practice.

9. Having thus completed the principal adjustments in their proper order, bring the telescope and its bubble-case as nearly vertical in the wye bearings as hand and eye can make them, and by reference to a plumb-line, or the corner of a well-built house, see if the vertical hair is out of true. If so, slightly loosen two opposite screws of the diaphragm, and correct the error by turning it. Try again the adjustment of the line of collimation before pinning up the wyes.

XI.

LEVELLING.

1. Suppose O the starting-point; 1, 2, 3, &c., the stakes of survey; and A the initial bench-mark. Wherever convenient the elevation of A above mean tide should be ascertained. It is to be regretted that this was not done from the outset, under statute provisions requiring maps and profiles also to be filed at the several State capitals. In that case, not only would much after labor and expense by way of duplicate surveys have been spared, but the older Commonwealths would now have in hand materials for the preparation of physiographical maps, the value of which to science, to the engineer, and to the economical geologist, it were hard to measure.



2. For the purposes of a railroad-survey, however, such determination is not needful. Any elevation may be assumed for A, taking care only that it be large enough to avoid the possibility of having minus levels, which would be inconvenient. Zero of the datum should be below the lowest probable ground on the contemplated line.

3. Let the elevation of the initial bench-mark, A, in the figure, be taken at +200. Set the level at B, and suppose the rod on the B M to read 2.22. The "instrument height" then is 202.22. If the rod at sta. O reads 8.4, the elevation at that point is 202.22 − 8.4 = 193.8. The rod reading 1.9 at sta. 1, the elevation there is 202.2 − 1.9 = 200.3. If desirable to turn at sta. 2, drive a pin nearly to the ground at that stake; suppose the rod on it to read 0.81. The elevation then is 202.22 − 0.81 = 201.41. Now move the instrument to C, and, sighting back to sta. 2, let the rod standing on the pin read 2.64. This makes the new "instrument height" at C = 201.41, the height of sta. 2, + 2.64 = 204.05, and the elevations at 3, 4, 5, or other points observed from C are found by deducting the readings at those points from the ascertained instrument height at the new point of observation.

4. It thus appears how simple is the rule of levelling, namely: Find the "instrument height" by adding the "back-sight" to the elevation of the point upon which the rod stands for that purpose: from the "instrument height" thus found deduct the "foresights," severally, in order to find the elevations of the points at which such foresights are taken.

5. The foregoing example would appear in the field-book as follows:—

STA.	B. S.	INST.	F. S.	ELEVA.	REMARKS.
B M	..	..	..	200.00	B M on W. Oak.
..	2.22	202.22	..	..	40 ft. N. of Sta. O.
0	..	..	8.4	193.8	
1	..	..	1.9	200.3	
2	..	..	0.81	201.41	
..	2.64	204.05	..	..	
3	..	..	3.7	200.3	
4	..	..	3.2	200.8	
5	..	..	10.36	193.69	

6. In levelling where great exactness is necessary, the rod at turning-points should be read to thousandths, and the reading *checked by the leveller*. Before taking it down, after clamp-

ing the target fast, it should be swayed slowly to and fro in the direction of the instrument to make sure of getting the full height. In foul weather the rodman should take care that the foot of the rod does not ball up with mud or snow. The leveller should have his cross-hairs free from parallax, the target in focus, and see his bubble true at the moment of observation. He should also set the instrument about half-way between turning-points when practicable, balancing largely unequal sights by subsequent ones similarly unequal in the opposite direction; and his turning-points, even on favorable ground, ought not to be more than 600 or 800 feet asunder.

7. On ordinary railroad field work such nicety as is implied in most of these rules is not required. To read to the nearest tenth is sufficient, especially where the progress of the party depends in a good degree on the level; as, for example, in running grade lines on preliminary survey. The location levels are usually carried along more carefully; but even then the writer's practice has been to turn to hundredths only.

8. *The Philadelphia Rod* is the best for our service. The sliding halves are unconnected except by brass sleeves or clips, which guide them, and are therefore not liable to bind in wet weather. They are made by William J. Young's Sons, who some years ago, at the writer's suggestion, supplied what seemed to be their only defect by adopting rivets for fastening the clips instead of wood screws: the screws had a tendency to work loose in the field, and cause the parts to chafe or jam. These rods are clearly figured, so as to be legible at a distance of several hundred feet; the leveller is thus enabled to take intermediate elevations rapidly, and, when necessary, to do his work with the aid of an unlettered rodman.

9. CORRECTION FOR THE EARTH'S CURVATURE AND REFRACTION.

The correction for a 100-feet "station" is .000215; for one mile, 0.6. It is to be added to the calculated elevation of the point observed, or to be deducted from the "rod" before calculating the elevation, in the case of a long unbalanced sight. It varies as the square of the distance. Calling the required correction A, for any given distance D, then $A = .000215 \times D^2$ if D is in "stations," and $A = 0.6 \times D^2$ if D is in miles. Thus the correction for 10 stations would be

.0215; for 50 stations, 0.5375; for 10 miles, 60 feet, and a spire or treetop apparently level with the instrument at that distance would really be 60 feet above it. Transposing the equation we have $D = \sqrt{A \div 0.6}$. In this form it is applicable to the determination of distances at sea. The Peak of Teneriffe, for example, 16,000 feet high, should be just visible from the sea-level at a distance $= \sqrt{16000 \div 0.6}$ = say 163 miles.

10. TO FIND DIFFERENCES IN ELEVATION BY MEANS OF THE BAROMETER.

Call the required difference D; the barometrical reading at the lower stand, L; that at the upper stand, U.

$$\text{Then, } D = (L - U) + (L + U) \times 55000.$$

Example.

$L = 26.64$; $U = 20.82$.

Then, $L - U = 5.82$ . . . . log. 0.764923
$L + U = 47.46$ . . . . log. 1.676328
0.1226 . . . . Diff. −1.088595

And $0.1226 \times 55000 = 6743$, the required difference of elevation in feet.

11. A closer approximation is thought to be attainable by using a thermometer in connection with the mercurial barometer. In that case, having found the difference as above, add $\frac{1}{440}$ of the result for each degree by which the mean temperature of the air at the two stands exceeds 55°; subtract the like proportion if the mean temperature be below 55°. When the upper thermometer reads highest, for "subtract" say "add," and *vice versa* in the foregoing rule.

12. The naked formula, however, will usually be sufficient for the engineer. He can prescribe gradients by it for surveys, which shall develop the ground to be occupied, and can decide between summits well differenced in height. If not so differenced, questions of detour, of approaches, and the like, will contribute to determine the expediency of making an instrumental examination.

13. HEIGHTS BY THE THERMOMETER.

T = the difference, in degrees Fahrenheit, between 212°, the *temperature of boiling* water at the sea level, and that at the *place of observation.*

II = the height of place of observation above or below the sea in feet.

$$H = 513\,T + T^2.$$

Example.

$$T = 212° - 208° = 4°.$$
$$H = (513 \times 4) + 4^2 = 2068 \text{ feet.}$$

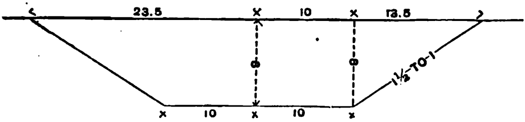
XII.

SETTING SLOPE STAKES.

1. Like swallowing, this is more easily done than described. To no detail of field service does the proverb more fitly apply, that "work makes the workman."

2. The problem is, to find where a formation slope of given inclination, beginning at the side of the road-bed, must needs intersect the ground surface. Formation slopes are usually stated in parts horizontal to one part vertical. Thus a slope of 45° is "1 to 1." A slope of "2 to 1" has a horizontal reach of two feet to each foot vertical. The carriages of a stairway with twelve-inch treads and eight-inch risers would have a slope of "1½ to 1."

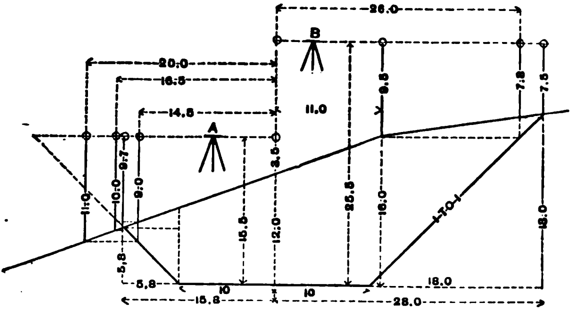
3. To fix the point where any proposed formation slope must meet the surface on level ground, is quite simple; the distance from the centre line being obviously made up of half the width of road-bed added to the horizontal distance due from the slope, to the depth of cut or height of fill. Thus, with 20 feet road-bed, 9 feet cut, and slope of 1½ to 1, the distance out would be 10 + 9 + 4½ = 23½ feet, as shown in the annexed diagram.



4. *On slant or* broken ground, the solution is more difficult: *se must then* be had to the level, with a rodman, a tape-
', *for good* speed, an axeman to assist.

Example No. 1.

5. Let the accompanying figure represent the cross-section at any given point of a proposed excavation; road-bed 20 feet wide, cutting at centre stake 12 feet, and formation slopes 1 to 1.



6. The first step is to set the level, as at A, commanding, let us suppose, the lower slope, and to ascertain its height above grade at the proposed section. This is usually done by reference to the nearest bench, and pegging from stake to stake as the work progresses. Unless the ground is very steep, and the slope-stakes largely different in elevation, labor will be saved and likelihood of error reduced by levelling over the centre line beforehand, as a separate job, and marking on centre stakes the cuts, fills, and grade points, that is to say, the points where excavation passes into embankment. The rods should be taken carefully *at* the stakes, and the latter marked on their backs to the nearest tenth, as "grade," "C 12," signifying *cut 12 feet*, or "F 6.2," signifying *fill 6.2 feet*, for example. This being done, each centre stake serves as a benchmark for slope staking at that section, and each cross section can be staked out independently.

7. Instrument height, in the example treated, being by either method fixed at 15.5 above grade, the next step is a guess how far out from the centre stake the formation slope would probably meet the ground surface. The closeness of the guess will correspond to the experience and natural skill of the leveller: the young engineer should not be discouraged if he misses t mark rather widely in his early trials.

8. It is true, that, on a uniform declivity, he might aid conjecture by taking a rod distant half the width of road-bed, or 10 feet, from the centre stake, ascertain thus the slope of the ground surface as well as the cutting at that point; and with these data, knowing also the formation slope, approximate the point sought by solving the terminal triangle of the proposed section, indicated by dotted lines in the figure. But, in practice, he will find it the quicker and better way to approximate the point by vividly imagining the underground formation lines; or by vividly imagining a level section, the upper surface of which shall coincide with his instrument height, 15.5 feet above grade. This gives him a point in the air, $10 + 15.5 = 25.5$ feet out from the centre stake, level with the instrument, as the limit of the imaginary section; and from that point he can pretty well judge where a line corresponding to the formation slope must meet the ground.

9. Suppose him, by either method, or even by random guess, to think that 10 feet for half the road-bed, and 10 more for the slope, looks about right. The formation slope being 1 to 1, this implies a cutting of 10 feet at the side stake, and a rod, therefore, of $15.5 - 10.0 = 5.5$ feet. Taking a rod accordingly, 20 feet out, measured horizontally from the centre stake, he finds it to be 11.0 instead of 5.5, indicating that he has gone too far down hill. Let him now reason that the rod of 11.0 corresponds to a cutting of $15.5 - 11.0 = 4.5$ feet, and that a cutting of 4.5 feet corresponds to a distance out of $10 + 4.5 = 14.5$ feet. Try, then, a rod 14.5 feet out. It proves to be 9.0, corresponding to a cutting of $15.5 - 9.0 = 6.5$, instead of 4.5 feet, and a distance out of 16.5 instead of 14.5 feet. Try, next, 16.5 feet out; the rod there, of 10.0 instead of 9.0, shows him again to be in error on the down-hill side of his object; but the lessening error shows also that he is approaching it, and that a few more like trials will reach it.

10. Recurring to his first error with the 11.0 feet rod, he cannot fail to observe after a little practice, since the ground ascends thence toward the centre line, that the side stake must fall farther out than the point where his second trial was made; that its true position, in fact, divides the distance between those points of observation into two parts which are to one another directly as the inclinations of the formation slope *and the ground surface.* By degrees he will grow skilful in *divining this true position*, and, becoming meanwhile quick in

observation, will place a slope stake on the second or third trial, without conscious effort of mind.

11. Next, suppose the level at B, 25.5 feet above grade, commanding the upper slope.

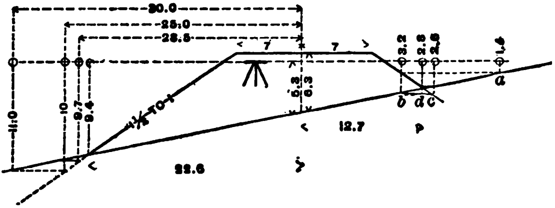
Note the change of ground 11 feet out, and take a rod there, recording the observation. The cutting at that point is 25.5 — 9.5 = 16 feet, corresponding to a distance out for the side stake of 10 + 16 = 26 feet, if the ground were level. A trial rod 26 feet out reads 7.8, corresponding to a cutting of 25.5 — 7.8 = 17.7 feet, and a distance out for the side stake of 10 + 17.7 = 27.7 feet, showing that the point sought is still beyond. A repetition of such trials will finally fix it; but, as in the case of the lower slope, practice will speedily lessen the number and abridge the labor of them.

12. The foregoing section would be noted in the field book as follows: —

STA.	DIS.	LEFT.		CENTRE	RIGHT.		AREA.	C. YDS
258	50	$\frac{+5.8}{15.8}$		+12.0	$\frac{+16.0}{11.0}$	$\frac{+18.0}{28.0}$		

Example No. 2.

13. In the annexed figure, representing an embankment 14 feet wide on top, with side slopes of 1½ to 1, the first thing to attract attention is that the instrument is 1 foot *below grade*, and that, therefore, 1.0 is to be *added* to all rods, in order to find the height of embankment above the points at which rods are taken.

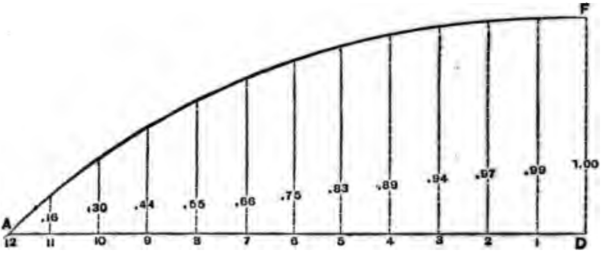


14. Consider the down-hill side. The engineer, with the *ground in view*, and with the height of embankment at the

XIII.

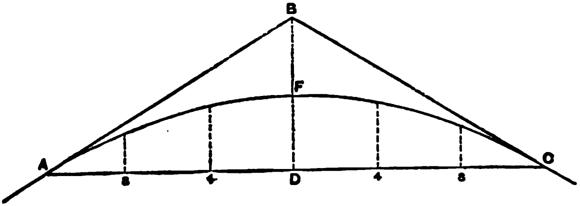
VERTICAL CURVES.

DIAGRAM GIVING THE ORDINATES OF A PARABOLA AT INTERVALS OF $\frac{1}{24}$ TO THE SPAN, THE MIDDLE ORDINATE BEING UNITY.



1. Suppose gradients descending right and left at an equal rate from the summit B, and that it is required to truncate the summit with a vertical curve extending 150 feet each way.

A circular arc consuming so small an angle may be treated as a parabola, in which the external secant B F is equal to the versed sine F D. Referring to the above diagram, ordinates 4 and 8 will be seen to correspond to the ordinates between chord A C and the curve in this instance, which ordinates therefore will be equal to the middle ordinate F D multiplied by 0.89 and 0.55 respectively. Adding these multiples to the grade elevation at A, the elevations of the intermediate points selected will be ascertained.

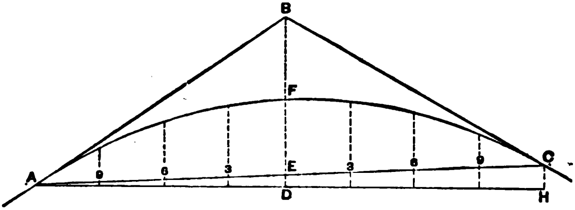


Example 1.

Elevation at $A = +94.0$; $AB = +1$ in 100; $BC = -1$ in 100; AD, DC, each $= 150$ feet or 1.5 stations of 100 feet each.

Hence $BD = 1.5$; and $FD = 0.75$ feet.
Ordinate $8 = 0.75 \times 0.55 = 0.41$.
Ordinate $4 = 0.75 \times 0.89 = 0.67$.
Elevation of grade at $8 - 8 = 94.0 + 0.41 = 94.41$.
Elevation of grade at $4 - 4 = 94.0 + 0.67 = 94.67$.
Elevation of grade at $D = 94.0 + 0.75 = 94.75$.

Example 2.



Elevation at $A = +94.0$. $AB = +1$ in 100; $BC = -0.4$ in 100; AH, level; AD, DH, each $= 200$ feet, or 2 stations, divided into 50 feet spaces, the points of division corresponding therefore to ordinates 3, 6, and 9 of the preceding diagram.

$$CH = 1 \times 2 - 0.4 \times 2 = 2.0 - 0.8 = 1.2 \text{ feet.}$$

Ascent from A to C along chord $AC = CH \div 8 = 1.2 \div 8 = 0.15$ per 50 feet.

$BE = BD - \frac{1}{2} CH = 2 - 0.6 = 1.4$.
$\therefore FE = 1.4 \div 2 = 0.7$.
Ordinates at $9 - 9 = 0.7 \times 0.44 = 0.31$.
Ordinates at $6 - 6 = 0.7 \times 0.75 = 0.52$.
Ordinates at $3 - 3 = 0.7 \times 0.94 = 0.66$.
Mid-ordinate $= 0.70$.

The elevations then along the chord AC, ascending at the rate of 0.15 per 50 feet, will be:—

A	9	6	3	0	3	6	9	C
94.0	*94.15*	*94.30*	94.45	94.60	94.75	94.90	95.05	95.20

to which add the ordinates just found:—

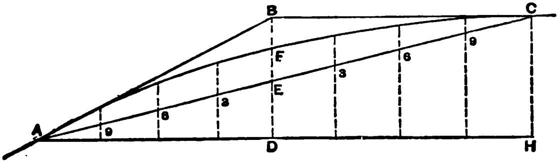
0.0 0.31 0.52 0.66 0.70 0.66 0.52 0.31 0.0

and the grade elevations on the curve will be:—

94.0 94.46 94.82 95.11 95.30 95.41 95.42 95.36 95.2

Example 3.

Elevation at A = + 94.0; A B = + 1 in 100; B C, A H, level. A D, B C, each 200 feet divided into 50-feet spaces, the points



of division corresponding therefore to ordinates 3, 6, and 9 of the ordinate diagram C H = 1 × 2 = 2 feet.

Ascent from A to C along chord A C = C H ÷ 8 = 0.25 per 50 feet.

B E = B D — ½ C H = 1 foot.
∴ F E = 1 ÷ 2 = 0.5.
Ordinates 9 — 9 = 0.5 × 0.44 = 0.22.
Ordinates 6 — 6 = 0.5 × 0.75 = 0.37.
Ordinates 3 — 3 = 0.5 × 0.94 = 0.47.
Mid. ordinate = = 0.50.

The elevations then along the chord A C, ascending at the rate of 0.25 per 50 feet, will be:—

A	9	6	3	0	3	6	9	C
94.0	94.25	94.5	94.75	95.0	95.25	95.5	95.75	96.0

to which add the ordinates just found:—

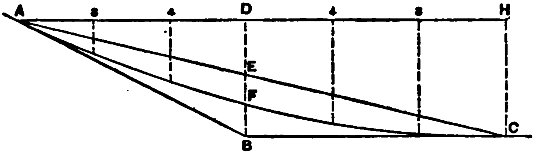
0.0 0.22 0.37 0.47 0.5 0.47 0.37 0.22 0.0

And the grade elevations on the curve will be:—

94.0 94.47 94.87 95.22 95.5 95.72 95.87 95.97 96.0

Example 4.

Elevation at A = + 94.0; A B = — 1 in 100; B C, A H, level; A D, B C, each 150 feet, divided into 50-feet spaces, the points of division corresponding therefore to ordinates 8 and 4 of the initial diagram C H = 1 × 1.5 = 1.5.



Descent from A to C along chord A C = C H ÷ 6 = 0.25.

E B = D B — D E = 1.5 — 0.75 = 0.75
∴ F E = 0.75 ÷ 2 = 0.375
Ordinates 8 — 8 = 0.375 × 55 = 0.21
Ordinates 4 — 4 = 0.375 × 89 = 0.33
Mid ordinate = 0.37

The elevations then along the chord A C, descending at the rate of 0.25 per 50 feet, will be:—

A	8	4	0	4	8	C
94.0	93.75	93.5	93.25	93.0	92.75	92.5

From which deduct the ordinates just found,

0.0 0.21 0.33 0.37 0.33 0.21 0.0

And the grade elevations on the curve will be:—

94.0 93.54 93.17 92.88 92.67 92.54 92.5

The figures are drawn much distorted, in order to make the illustration clear.

2. With profile paper at hand, a convenient and quite sufficient determination of the grade elevations on a vertical curve may be made by drawing the gradients to a scale of 2 feet to an inch vertical, and 50 feet to an inch horizontal. By means of the curve *protractor* (Art. XXV. 1) a suitable arc may *then be fitted and struck* in, and the elevations read off.

XIV.

THE TRANSIT.

1. Should the vernier and circle plates be out of parallel, — should one or the other be sprung, a defect shown by a slight rocking motion when the rims are pinched alternately on opposite sides, — the instrument must be sent to the shop for repair. This is a common disease of transits in their old age: instrument-makers need to study its cause and cure.

2. TO ADJUST THE LEVEL TUBES.

Bring the bubbles to the middle of them by means of the levelling screws. Turn the top of the instrument horizontally half way round. If the bubbles then err, reduce the error one-half with the small adjusting screws attached to the tubes, and one-half with the levelling screws. Repeat until the adjustment is perfect.

3. TO ADJUST THE VERTICAL HAIR SO THAT IT SHALL REVOLVE IN A PLANE, AND MARK BACKSIGHT AND FORESIGHT POINTS IN THE SAME STRAIGHT LINE.

Try, first, by reference to the corner of a well-built house, or to a plumb-line, whether the hair be truly vertical. If it is not, loosen the four small capstan head screws on the outside of the barrel slightly, and gently tap the topmost one right or left, until the adjustment is effected.

4. Then, after bringing the four screws to a snug bearing again, direct the cross-hair to the edge of some well-defined object, as a chain pin, or stake, placed 400 or 600 feet distant. Upset the telescope, and place a like mark at about the same distance, and level in the opposite direction. Unclamp. Revolve the instrument horizontally on its spindle half way round, and direct the cross-hair to the point first observed. *Again upset* the telescope. If the cross-hair now strikes aside *from the second mark,* correct one-quarter of the error by *means of the lateral* capstan head screws on the barrel, and

one-quarter with the tangent screw. Repeat until the adjustment is effected. An experienced transitman will generally prefer to make this adjustment without aid, points in range being readily found.

5. Having thus brought the cross-hair to revolve in a plane, it is next to be seen whether the plane in which it revolves is truly vertical. To do so, set the instrument near the base of some lofty point, as a church spire or chimney, on which point direct the cross-hair, and then, tilting the object end of the telescope downwards, set a pin, or make a pencil dot in line. Unclamp the spindle; turn the instrument horizontally halfway round; clamp fast; fix the cross-hair again on the lower point, and try it on the upper one. If it misses, correct half the error by means of the adjusting screws now usually provided, at one of the bearings of the cross-bar; or, if these be lacking, by filing off the feet of the standard which supports the higher end of the cross-bar.

6. TO ADJUST THE NEEDLE.

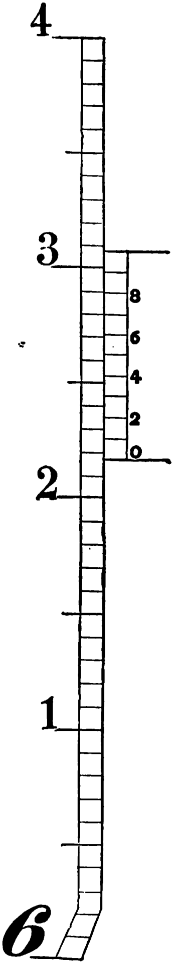
Having removed the cap, and placed the instrument conveniently in a still room, push one end of the needle a little aside from the point where it tends to settle, and exactly to some figured division line on the graduated circle. There gently stay it in position by means of a small wooden block, an ivory die, or the like. Observe where the opposite end strikes. If between graduation lines, mark the precise spot with a sharp pencil. Turn the needle end for end, and stay the reverse point at the division line first observed. Again spot with the pencil where the opposite end stakes. Midway of these two pencil spots make another. Take the needle off the pivot, and bend it this way or that, until, by repeated trials, when replaced with one end stayed at the division line first observed, the other shall cut the midway pencil spot.

7. The needle being thus straightened, proceed to rectify the position of the centre pin, if necessary, by bending it with nippers so that the needle shall cut opposite degrees at the quarter points of the circle.

XV.

MISCELLANEOUS.

THE VERNIER.

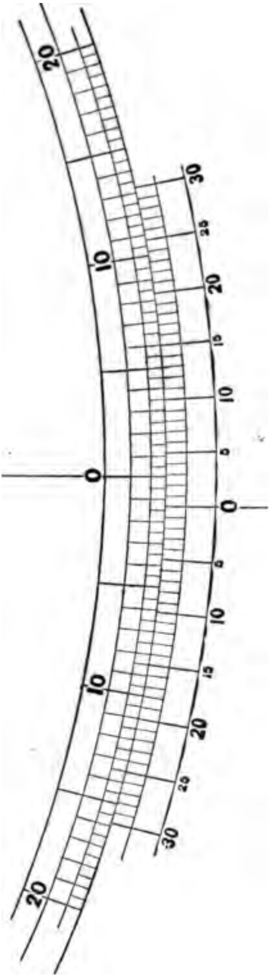


1. The vernier in the transit is a short graduated arc, movable around the graduated circle of the instrument, by means of which subdivisions of the circle graduation can be read. There are many varieties of the vernier; but a knowledge of the principle upon which one is made introduces the student to an easy acquaintance with all.

2. Suppose the tenth part of a foot to be marked off on a straight edge into ten equal parts, and that on another straight edge a space equal in length to nine of these parts is divided also into ten equal parts. The subdivisions of the latter scale will then each be nine-tenths as large as the subdivisions of the former; and if the graduated edges are placed together, with the zero marks in both exactly lined, the first mark of the latter, or vernier, scale will fall short of the first mark of the former, or limb, so to speak, by one-tenth part of the first space on the limb; that is to say, by one-tenth part of one-hundredth of a foot, or one-thousandth of a foot. The second mark of the vernier will fall short of the second mark of the limb by two-thousandths of a foot, and so on. If, therefore, the vernier scale be moved slowly forward, the successive oppositions of the scale marks will indicate successive advances of the vernier, each equal to the one-thousandth part of a foot. The marginal example reads 6.217 = six feet, two-tenths, one-hundredth, and seven-*thousandths*.

3. The annexed figure represents the transit

vernier, together with a part of the graduated circle. Th



vernier is a double one, for convenience in reading angles right or left. It will be observed that a space, equal to twenty-nine half degrees on the limb, is laid off from zero each way on the vernier, and there subdivided, on both sides of zero, into thirty equal parts. If now the zeros are brought into line, the first marks of the vernier right and left will fall one-thirtieth part of a half degree short of the first, or half-degree marks on the limb; that is to say, one minute short. The vernier, therefore, is scaled to read minutes; and, if its zero mark be moved slowly half a degree on the limb, its several subdivision marks, one after another in arithmetical succession, will be seen to line with marks of the limb until the thirtieth is reached, when zero will be found to have traversed the half degree space.

4. TO READ AN ANGLE.

First note whether the vernier has been moved right or left; then observe on the limb the number of full degrees, and the half-degree, if any, which zero of the vernier has passed; next, look along the vernier from its zero towards the right, if the movement has been towards the right, and from zero towards the left, if the movement has been towards the left, until a "minute" mark is found exactly in line with some mark on the limb. Add the number of that minute mark on the vernier to the angle already ascertained within half a degree from the limb: the sum will be the angle sought. The vernier in the figure reads 1° 20′ L.

5. In some respects a vernier graduated decimally would be more convenient on railroad locations, where the 100-feet chain is used; the calculation of engineers' tables to sixtieths of a degree has prevented its adoption.

6. TO RE-MAGNETIZE A NEEDLE.

Lay the north half flat on a smooth, hard surface, and with gentle pressure draw the south pole of a common magnet over it, from the centre outwards, withdrawing the magnet from it six or eight inches after each pass. Repeat ten or a dozen times. Treat the south half of the needle in the same manner with the north pole of the magnet. Replace the balancing wire. If the needle yet proves to be sluggish, take out the centre pin, and newly point and polish it.

7. If the needle, by reason of electricity, clings to the covering glass in the field, a touch of the moist finger to the top of the cover will release it.

8. Do not suffer idlers to play it about with knives, keys, and the like.

9. When the instrument is out of use, leave the needle free.

10. TO REPLACE CROSS-HAIRS.

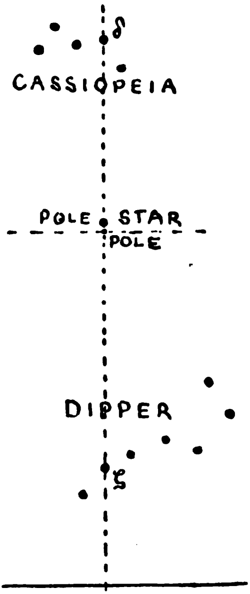
Take out the eye-glass tube. Remove the small lateral capstan head screws which hold the cross-hair ring athwart the barrel. Loosen the vertical screws, and, taking care throughout to observe the position of the ring, in order that it may be got back again right side up and right face forward, turn it lengthwise of the barrel. Insert the end of a pine sliver into one of the side holes, take out the vertical screws, and withdraw the ring. Stretch across new hairs, in the scores traced for them, of the finest clean spider-line; secure them with a touch of gum or wax, and put the ring in by a reverse process.

11. TO FIX A TRUE MERIDIAN.

By equal shadows of the sun.

On level ground or ice, set up a pole. Two or three hours before noon, mark the extremity of its shadow. With radius reaching to that mark, from a centre on the surface vertically below the top of pole, strike an arc eastward. Two or three hours after noon, watch for the moment when the extremity of the shadow touches the arc. There make another mark. The true meridian will pass from the centre midway between the two marks, if the observations be made about the period of the solstice, in June or December. The method gives a fair approximation at any time of year.

12. *By observation of the North Star in meridian.*



Polaris, or the North Star, being not exactly at the pole, revolves around it through a small circle. It is therefore due north of an observer only when vertically above or below the pole. To observe it at either of these points, reference is had to certain bright stars which are in vertical range with it near the time of culmination. Its vertical range with either of the reference stars being observed, the true meridian may be set out by means of a direct observation of Polaris at an interval of time thereafter derived from the accompanying table.

The stars thus used are, *first*, the middle star of the three composing the handle of the Dipper, called ζ *Ursæ Majoris*; *second*, the star called δ, at the foot of the first stroke of the W in the constellation *Cassiopeia*, which lies opposite the Dipper, at about an equal distance from the pole. Of course, when one of these stars is in upper, the other is in lower culmination; and the approximate time for observation may be found in Table I., giving the culminations of Polaris. At present, Jan. 1, 1890, the Pole Star culminates not quite one minute *earlier* than it comes to the same vertical with ζ Ursæ Majoris—a fact indicated by the negative sign in the annexed table. The two stars will culminate together two and a half years hence.

The following table gives, with sufficient accuracy for any latitude in the United States south of Alaska, and for either the upper or the lower culminations of these bright stars, the value of the time interval, and the annual increase thereof in minutes, between the moment of vertical coincidence, and the moment of the culmination of Polaris.

		Min.		*Min.*
For ζ *Ursæ Majoris*	in 1890	− 0.9	Annual increase	+ 0.35
	in 1900	+ 2.6		
For δ *Cassiopeia*	in 1890	+ 0.1	Annual increase	+ 0.33
	in 1900	+ 3.4		

To establish the meridian, choose still weather, hang a plumb-bob from some high fixed object into a bucket of water, that it may be both free and steadfast, and select a place of observation so far southward that the plumb-line shall cover the breadth of sky between the reference star and the pole,—the farther the better. The point of observation may be an upright bodkin or compass-sight, fastened to a block movable horizontally eastward and westward. Watch for the moment when, from the point of observation, the plumb-line covers Polaris and the reference star. On the lapse of the tabular interval thereafter bring the plumb-line in range with Polaris by shifting the observation point laterally. That range will be the true meridian. Stakes may be set on it forthwith by means of candles.

If the star in Cassiopeia be used within the coming two and a half years, attention is directed to the negative time interval. Its treatment hardly needs exposition.

With a transit the plumb-line is not necessary, but special care should be taken to adjust the vertical thread of the telescope, and the horizontality of its transverse axis. This is best done by sighting up and down a fine cord or wire suspending a plummet in water. When making observations at night the cross hairs may be illuminated by reflecting light on the object glass from white paper.

13. *By observation of the North Star at its extreme elongation.*

Find the time in Table II., and make the preparations above directed. Keep the plumb-line in range with the star until the star apparently ceases to move. Mark that range. Multiply the natural tangent of the azimuth, given in Table III., by the distance in feet from the point of observation to the mark in the northern range just set. The product will be the distance from said northern range mark, square right or left, to a point in the true meridian passing through the point of observation. If the western elongation was observed, set off the calculated distance eastward from the northern range mark; if the eastern elongation was observed, set the distance off westward. If both the eastern and western elongations be observed, the true meridian will pass through the point of observation, bisecting the angle between the northern range marks.

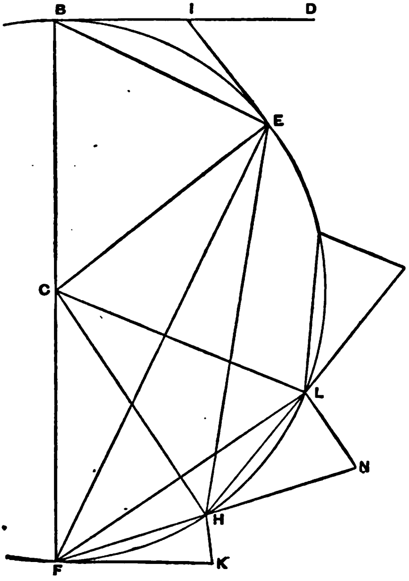
With a vernier instrument, the azimuth can be laid off directly, in degrees and minutes.

PROPOSITIONS AND PROBLEMS RELATING TO THE CIRCLE.

XVI.

PROPOSITIONS RELATING TO THE CIRCLE.

The following propositions, demonstrable by simple process of geometrical reasoning, may be regarded as axiomatic.



1. In any circle a tangent is perpendicular to radius at t tangent point. Thus, B I is perpendicular to B C.

2. Tangents drawn to a circle from the same point are equal. Thus, I B = I E.

3. The angle D I E, at the intersection of tangents, is equal to the central angle B C E, included between radii to the tangent points.

4. If a chord B E connect the tangent points, the angles I B E, I E B, are equal: each of them is equal to half of the central angle B C E, or of the intersection angle D I E.

5. Any angle, B C E, at the centre, subtended by the chord B E, is double the angle B F E, at the circumference, on the same side of the chord B E.

6. Acute angles at the circumference, subtended by equal chords, are equal.

7. An acute angle, K F H, between a tangent and a chord, is called a *tangential angle*, and is equal to the peripheral angle L F H subtended by an equal chord; each is equal to half the central angles F C H, or H C L, subdivided by the same chords.

8. The exterior angle L H N at the circumference, between two equal chords, is called a *deflection angle:* it is equal to the central angle, or to twice the tangential angle, subtended by either chord.

9. If F K be made equal to F H, and H N be made equal to H L, H K is called the *tangential distance*, and L N the *deflection distance.*

10. The exterior angle E H N at the circumference, between two unequal chords, is equal to the sum of their tangential angles, or to half the sum of their central angles.

XVII.

CIRCULAR CURVES ON RAILROADS.

1. The circle is divided, for convenience, into 360 equal parts, called degrees. A circle 36,000 feet in circumference would be cut by such subdivision into 360 parts, each 100 feet long, and subtending an angle of one degree at the centre; its radius would be 5,729.6 feet, usually reckoned 5,730 feet. The

chain 100 feet long being the unit generally adopted by American engineers for field measurements, any circular arc having that radius, of 5,730 feet, is called a *one-degree curve*, for the reason that one chain is equivalent to an arc of one degree at the circumference.

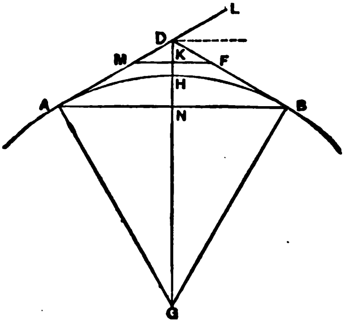
2. The circumferences of circles vary directly as their radii: hence, in any circular arc struck with half that radius, or 2,865 feet, one hundred feet at the circumference would subtend an angle of two degrees at the centre. Such an arc is called a *two-degree curve*. If one-third of the primary radius of 5,730 feet, or 1,910 feet, be used, the arc is called a *three-degree curve;* and so on.

3. It should be borne in mind, however, that these measurements are supposed to be made around the arc itself, and not on lines of chords. Since field measurements with the chain are always made on the lines of the chords, which are shorter between given points at the circumference than the lines of the arcs, as a bowstring is shorter than the bow, it is plain that, in advancing towards the centre of the one-degree curve by a series of concentric circles having radii equal to *one-half*, *one-third*, &c., of the primary radius, the chord 100 feet long differs more and more in length from the arc subtended by it, the bow being more and more arched in relation to the string. Thus, in the circle having a radius equal to *one-twentieth* of the primary radius, the chord 100 feet long subtends an angle of 20° 06′, at the centre, instead of 20°, and the arc is 100.5 feet in length, instead of 100 feet. In order, therefore, that the chord of 100 feet may subtend arcs of 1°, 2°, 3°, &c., in regular succession, the radii of these successive arcs must be somewhat greater than the above method by subdivision of the primary radius would make them; though, as might be inferred from the extreme case given by way of illustration, the difference is not appreciable in ordinary field practice, and radii, together with all the functions dependent on them, may usually be held to vary as the *degree of curvature*, or central angle per 100 feet chord, varies.

XVIII.

TO FIND THE RADIUS, THE APEX DISTANCE, THE LENGTH, THE DEGREE, ETC., OF A CURVE.

1. Let D B, A L be two straight lines intersecting at D. Lay off equal distances, D A, D B; erect perpendiculars at A and B, meeting at G, and connect A B, D G. From the centre G, with radius G A, draw the curve A H B.



The point D will be the P. I.; A and B, tangent points; D A, D B, the tangents, or apex distances, which denote by AD; D H, the external secant, or S; H N, the middle ord, or O. Let the long chord A B, connecting the tangent points, be called C, and G A or G B, the radius, R. Call the deflection angle to a chord of 100 feet D, as before.

2. By XVI. 3 and 4, angle D A B = D B A = A G D = D G B = $\frac{1}{2}$ I.

3. GIVEN THE INTERSECTION ANGLE I AND RADIUS R, TO FIND THE APEX DIST. A D.

$AD = R \times \textit{tan.}\ \frac{1}{2} I.$

Example.

$R = 1{,}910.1,\ I = 35° 24'.$

Then $AD = R\ \textit{tan.}\ \frac{1}{2} I = 1{,}910.1 \times 0.3191 = 609.5.$

4. Measure from the P. I. equal distances, D M, D F, along the tangents. Measure, also, M F and D K, the distance from D to the middle point of M F. Then, by reason of similarity in the triangles M D K, D A G,

$$MK : DK :: AG : AD :: R : T$$
$$\therefore AD = R \times DK \div MK.$$

Example.

Let M K = 190.5, D K = 60.8, R = 1910.1.

Then R =	1910.1	3.281056
D K =	60.8	1.783904
M K =	190.5 (a.c.)	7.720105
A D =	609.6	2.785065

5. If 100-feet chords be used, find the ap. dist. in Table XVI. corresponding to the given angle I. Divide that tabular ap. dist. by the degree of curvature corresponding to the given radius: the quotient will be the required ap. dist. Thus, Tab. A D corresponding to 35° 24′ = 1,828.7, which, divided by 3, the degree of curvature, gives 609.6, the ap. dist. sought.

6. GIVEN THE INTERSECTION ANGLE I AND AP. DIST. A D, TO FIND RADIUS R.

Transposing the equation in (3),

$$R = A\,D \div tan.\ \tfrac{1}{2}\,I = A\,D \times cot.\ \tfrac{1}{2}\,I.$$

Example.

$A\,D = 609.6,\ I = 35°\ 24'\ R = A\,D\ cot.\ \tfrac{1}{2}\,I = 609.6 \times 3.1334 = 1910.1.$

By a like transposition of the equation in (4),

$$R = A\,D \times M\,K \div D\,K.$$

7. If 100-feet chords be used, find in Table XVI. the ap. dist. corresponding to the given angle I. Divide that tabular datum by the given ap. dist.; the quotient will be the degree of curvature in degrees and decimals. The radius corresponding to this degree of curvature may be found by (12), by Table X., or, with sufficient accuracy for ordinary practice, by dividing 5,730, the radius of a 1° curve, by it.

Thus, in the foregoing example, the tabular ap. dist. corresponding to 35° 24′ is 1,828.7. Dividing by 609.6, we have 3 for the degree of curvature; and 5,730 divided by 3 gives R = 1,910 feet.

8. GIVEN THE INTERSECTION ANGLE I AND CHORD A B = C, CONNECTING THE TANGENT POINTS, TO FIND RADIUS R.

$$A N = \tfrac{1}{2} A B = \tfrac{1}{2} C; \; A G N = \tfrac{1}{2} I.$$
$$A G = A N \div sin. \; A G N;$$
$$i.e., \; R = \tfrac{1}{2} C \div sin. \; \tfrac{1}{2} I.$$

Example.

$I = 35° \, 24'$, $C = 1161.4$.

Then $R = \frac{1}{2} C \div sin. \, \frac{1}{2} I, = 580.7 \div 0.304 = 1910.2$.

9. If 100-feet chords be used, find in Table XVI. the chord corresponding to the given angle I. Divide that chord by the given chord, for the degree of curvature in degrees and decimals. Determine the corresponding radius by (17), by Table X., or, for ordinary practice, by dividing 5,730 by it.

Thus, in the foregoing example, the tabular chord corresponding to angle 35° 24′ would be 3,484.2, which, divided by the given chord, 1,161.4, gives 3 for the degree of curvature, and 5,730 divided by 3 makes the radius R = 1,910 feet.

10. GIVEN THE INTERSECTION ANGLE I AND THE DEGREE OF CURVATURE OR DEFLECTION ANGLE D, WITH 100-FEET CHORDS, TO DETERMINE THE LENGTH OF THE LONG CHORD C, THE MIDDLE ORD. O, THE EXTERNAL SECANT S, OR THE APEX DIST. A D.

Take from the proper column in Table XVI., the number corresponding to the intersection angle, and divide it by the degree of curvature: the quotient will be the length required.

Example.

A 4° curve, I = 50° 16′; to find the several functions above named.

Table XVI. gives the designated functions of a 1° curve as follows: C 4,867.3, O 542.4, S 599.3, A D 2,688.2. Dividing by 4 the degree of curvature, we have for the corresponding functions of a 4° curve as follows: C 1,216.8, O 135.6, S 149.8, A D 672.0.

11. GIVEN C, O, S, OR A D, OF ANY CURVE, AND D, THE DEGREE OF CURVATURE, TO FIND THE INTERSECTION ANGLE, I.

Multiply the given function C, O, S, or A D, by the degree of curvature, D: the product will be found in the proper column of Table XVI., corresponding to the required angle.

Example 1.

Given A D = 515, D = 5°; to find I.

Then A D × D = 2,575, which corresponds in Table XVI. to 48° 24′ = I.

Example 2.

Given C = 1,656, D = 3°; to find I.

Then C × D = 4,968, which corresponds in Table XVI. to 51° 23′ = I.

12. GIVEN C, O, S, OR A D, OF ANY CURVE; AND THE INTERSECTION ANGLE I, TO FIND THE DEGREE OF CURVATURE D.

Take from the proper column of Table XVI. the number corresponding to the given angle I, and divide that tabular number by the length of the given part; the quotient will be D, in degrees and decimals.

Example 1.

Given A D = 587, I = 22° 26′; to find D.
The A D corresponding to I in Table XVI. is 1,136.3.

Then 1,136.3 ÷ 587 = 1.935 = 1° 56′ = D.

Example 2.

Given S = 64, I = 30° 25′, to find D.
The *Ex. Sec.* corresponding to I in Table XVI. is 208.

Then 208 ÷ 64 = 3.25 = 3° 15′ = D.

13. GIVEN THE INTERSECTION ANGLE I, AND DEFLECTION ANGLE D, TO FIND THE LENGTH OF THE CURVE.

Divide I by D: the quotient will be the number of chord lengths in the curve.

If the degree of curvature is a whole number, the more convenient method of effecting the division is, first, to reduce the minutes, if any, in I to decimals of a degree; then divide by the degree of curvature.

Example 1.

I = 20° 40′, D = 3°. 20° 40′ is equivalent to 20.67 degrees. Dividing by 3, we have 6.89 chord lengths for the length of the curve. If the chords, as is usual, are each 100 feet long, the length of the curve in this case will be 689 feet. If the chord lengths were 50 feet each, the length of the curve would be half this number of feet.

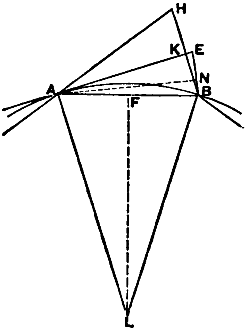
14. If the degree of curvature is fractional, the more convenient method of effecting the division is, first, to reduce both I and D to minutes; then divide the former by the latter.

Example 2.

I = 30° 22′, D = 2° 45′. These are equivalent, respectively, to 1,822 and 165 minutes. Dividing the former by the latter, we have 1,104 feet for the length of the curve.

15. The ingenious assistant who will attentively consider the preceding figures cannot fail to detect other obvious analogies which it has not been thought necessary to include in this compendium.

16. In railroad field practice it is usually sufficient to determine angles to the nearest minute, and distances to the nearest foot. The nicety of *seconds* and *tenths* appears generally to be quite superfluous; the time consumed on them were better employed in pushing ahead.



17. GIVEN ANY DEFLECTION ANGLE D, AND CHORD C, TO FIND RADIUS R.

$FB \div \sin.\ \tfrac{1}{2}\ ALB = BL$; *i.e.*, $\tfrac{1}{2}\ C \div \sin.\ \tfrac{1}{2}\ D = R$.

Example.

Let $C = 100$ feet, $D = 4°$.

Then $R = \tfrac{1}{2}\ C \div \sin.\ \tfrac{1}{2}\ D = 50 \div .0349 = 1432.7$.

If the chords are 100 feet long, as is usual in railroad practice, radius may be found with sufficient accuracy by dividing

5,730, the radius of a 1° curve, by the deflection angle, or *degree of curvature.* Thus, in the foregoing example, $5{,}730 \div 4 = 1{,}432.5$.

18. GIVEN ANY RADIUS R, AND CHORD C, TO FIND THE DEFLECTION ANGLE D.

From the preceding equation and example:—

$\mathit{Sin}\ \frac{1}{2}\,\mathrm{D} = \frac{1}{2}\,\mathrm{C} \div \mathrm{R} = 50 \div 1{,}432.7 = .0349 = \mathit{sin}\ 2^\circ = \frac{1}{2}\,\mathrm{D}$
$\therefore \mathrm{D} = 4^\circ$.

19. GIVEN ANY RADIUS R, AND CHORD C, TO FIND THE DEFLECTION DISTANCE *d*.

First find the deflection angle by above method (18). Then, angle H A B in the figure being made equal to D, and H A = B A, B H will be the deflection distance. Draw A K to the middle point of H B.

Then $d = \mathrm{HB} = 2\,\mathrm{KB} = 2\,\mathrm{AB} \times \mathit{sin}\ \mathrm{KAB} = 2\,\mathrm{C} \times \mathit{sin}\ \frac{1}{2}\,\mathrm{D}$.

Example.

Let $\mathrm{R} = 1{,}146$ feet, $\mathrm{C} = 100$ feet.
By (18) D will be found $= 5^\circ$.

$$\text{Then } d = 2\,\mathrm{C} \times \mathit{sin}\ \tfrac{1}{2}\,\mathrm{D} = 200 \times .0436 = 8.72 \text{ feet.}$$

20. If the chords are 100 feet long, as is usual in field measurement, divide the constant number 10,000 by the radius in feet: the quotient will be the deflection distance. The deflection distance with radius of 10,000 feet and chord of 100 feet is one foot: this rule is based upon the principle that deflection distances, the chord length being fixed, will vary inversely as the radii.

Thus, in the foregoing example, $10{,}000 \div 1{,}146 = 8.72$.

21. GIVEN ANY RADIUS R, AND CHORD C, TO FIND THE TANGENTIAL ANGLE T.

The angle T is equal to ½ D by construction; for mode of determining it, see preceding section (18).

22. GIVEN ANY RADIUS R, AND CHORD C, TO FIND THE TANGENTIAL DISTANCE t.

First find the tangential angle, as above directed. Then, angle B A E in the figure being made equal to T, and $AE = AB$, B E will be the tangential distance. Draw A N to the middle point of B E.

Then $t = EB = 2\,NB = 2\,AB \times \sin NAB = 2\,C \times \sin \frac{1}{2}T$.

Example.

Let $R = 1{,}146$ feet, $C = 100$ feet.
By sect. 1, T will be found $= 2° 30'$.

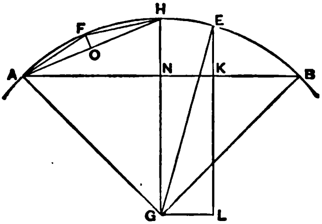
$$\text{Then } t = 2\,C \times \sin \tfrac{1}{2}T = 200 \times .0218 = 4.36 \text{ feet.}$$

23. In ordinary railroad practice the tangential distance may be considered equal to half the deflection distance.

XIX.

ORDINATES.

1. GIVEN ANY RADIUS R, AND CHORD C, TO FIND THE MIDDLE ORDINATE M.



In the annexed figure, $HN = M$, $HG = R$, $AB = C$.

$$NG = \sqrt{AG^2 - AN^2} = \sqrt{R^2 - \tfrac{1}{4}C^2}\,;\ HN = HG - NG,$$
$$i.e.,\ M = R - \sqrt{R^2 - \tfrac{1}{4}C^2}.$$

Example.

R = 819, C = 100; to find the middle ordinate, M.

$$M = 819 - \sqrt{670761 - 2500} = 1.53.$$

2. Angle $HAN = \frac{1}{2} HGB$; $HGB = \frac{1}{2} AGB$, $\therefore HAN = \frac{1}{4} AGB$.

$HN = AN \times tan.\ HAN$; i.e., $M = \frac{1}{2} C \times tan.\ \frac{1}{4} D$; D being the central angle subtended by the chord.

Example.

D = 7°, C = 100; to find M, the middle ordinate.

$$M = \frac{1}{2} C \times tan.\ \frac{1}{4} D = 50 \times 0.03055 = 1.528.$$

3. GIVEN THE RADIUS R, CHORD C, AND MIDDLE ORDINATE M, TO FIND ANY OTHER ORDINATE E K = M′, DISTANT *d* FROM N, THE MIDDLE POINT OF THE CHORD.

$KL = NG$; $NK = GL$; $EK = EL - NG$.

$$EL = \sqrt{GE^2 - NK^2} = \sqrt{R^2 - d^2};\ NG\ (1) = \sqrt{R^2 - \frac{1}{4} C^2}.$$

$$\text{Then } EK = M' = \sqrt{R^2 - d^2} - \sqrt{R^2 - \frac{1}{4} C^2}.$$

4. It is a property of the parabola, that ordinates vary as the products of their abscissas. This property may be assigned to the circle in cases where the arc encloses a small angle. Applying it here we have—

$$HN : EK :: AN \times NB : AK \times KB.$$

Call any segments A K, K B, of the chord, *a* and *b*.

$$\text{Then } M : M' :: \tfrac{1}{4} C^2 : ab,\ \therefore M' = M \times 4\,ab \div C^2.$$

Example.

M = 1.528, C = 100, *a* = 60, *b* = 40; to find M′.

$$M' = 1.528 \times 9600 \div 10000 = 1.528 \times 0.96 = 1.467.$$

5. Multiply the corresponding ordinate of a 1° curve from the annexed table by the degree of curvature: the product will be the ordinate sought.

ORDINATES OF A 1° CURVE, CHORD 100 FEET.

Middle Feet. 50	Feet. 45	Feet. 40	Feet. 35	Feet. 30	Feet. 25	Feet. 20	Feet. 15	Feet. 10	Feet. 5
Lengths of the Ordinates in Feet.									
.218	.216	.209	.198	.183	.164	.140	.111	.078	.041

Distances of the Ordinates from the End of the 100-feet Chord.

Example.

What is the ordinate of a 6° curve, 30 feet from the end of the 100-feet chord?

The corresponding tabular ordinate of a 1° curve is .183; which, multiplied by 6, gives 1.098, the required ordinate.

6. A quick way of laying off ordinates on the ground, and one sufficiently exact for the field, is, after fixing the point H by means of the middle ordinate H N, to stretch a line from H to A, and make the middle ordinate F O = ¼ H N; then from F to A and F to H, making the middle ordinates = ¼ F O; and so on.

7. A good track-layer will seldom require points at shorter intervals than 25 feet.

TRACING CURVES
AND
TURNING OBSTACLES IN THE FIELD.

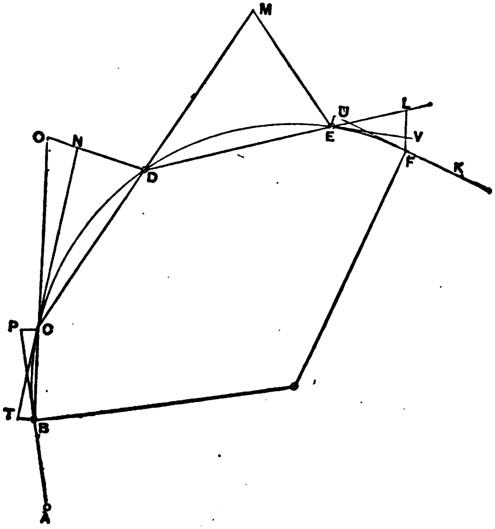
XX.–XXIII.

TRACING CURVES AND TURNING OBSTACLES IN THE FIELD.

XX.

TO TRACE A CURVE ON THE GROUND WITH THE CHAIN ONLY.

1. This is best taught by an example.



Example.

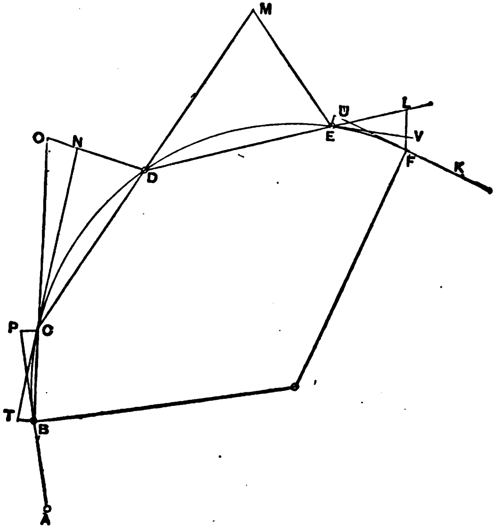
From a point B, 18 feet in advance of A, on tangent A B, to trace a curve of 367 feet radius to the right, with chords 66 feet long, and consuming an angle of 34° 27′.

RACING CURVES AND TURNING OBSTACLES IN THE FIELD.

XX.

TRACE A CURVE ON THE GROUND WITH THE CHAIN ONLY.

This is best taught by an example.



Example.

rom a point B, 18 feet in advance of A, on tangent A B, to *e a curve* of 367 feet radius to the right, with chords 66 feet , *and* consuming an angle of 34° 27'.

2. First, dividing half the unit chord, or 33 feet, by the radius, 367 feet (XVIII., 18), we have 0.09+ for the sine of the tangential angle, corresponding to an angle of 5° 10′: the deflection angle, therefore, is 10° 20′. The tangential distance corresponding to the angle 5° 10′, and chord 66 feet, is equal (XVIII., 22) to twice the chord multiplied by the sine of half the tangential angle, = 132 × 0.04507 = 5.95 feet. The deflection distance (XVIII., 19) is equal to twice the chord multiplied by the sine of half the deflection angle, = 132 × 0.09+ = 11.88, say 11.9 feet.

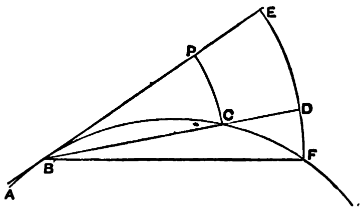
3. To find the length of the curve (XVIII., 13): Divide the total central angle by the degree of curvature. The central angle, 34° 27′, is equivalent to 2067 minutes; dividing by 620, the number of minutes in the deflection angle, we have 3.33, the number of chord lengths in the curve, = 3⅓ chains = 220 feet.

If A be a stake numbered 2, then the point of curvature, B, will be 2.18, and the point of tangent, F, will fall at 2.18 + 3.22 = stake 5.40.

4. To determine the tangential distance C P, to the first stake on the curve, either of two methods may be used: —

First, The sine of any tangential angle is equal to half the chord which limits the angle on one side divided by radius. The limiting chord B C in this instance is equal to 66 — 18 = 48 feet; half of 48, therefore, or 24 feet, divided by radius, 367 feet, gives 0.0654, the sine of 3° 45′ = tangential angle P B C. The sine of half this angle multiplied by twice the given chord = 0.0327 × 96 = 3.14 feet, the tangential distance C P.

5. *Secondly*, C P may be found as follows, assuming that the functions of small angles vary directly as the angles themselves, and *vice versa*.



Let B F be a portion of the curve. Make the tangent B E equal to the chord B F, and strike the arc E F. Draw the sub-chord B C, and strike the arc C P. Prolong B C to D. E F may be taken as the tangential distance due to the whole chord B F, and P C the tangential distance due to the sub-chord B C.

Then $PC : ED :: BC : BD$ or BF; and, by the foregoing supposition, $ED : EF :: BC : BF$. Combining these proportions, and cancelling ED, we have $PC : EF :: BC^2 : BF^2 \therefore PC = EF \times (BC \div BF)^2$.

In words, the tangential distance for a sub-chord is to that for a whole chord as the square of the sub-chord is to the square of the whole chord. The same is true of deflection distances.

6. In the example we are treating, the tangential distance for the whole chord of 66 feet has been found to be 5.95 feet; that for 48 feet, therefore, is $5.95 \times 48^2 \div 66^2 = 5.95 \times 0.528 = 3.14$, as before.

Stretch the 48 feet of chain from B to P, in prolongation of tangent A B, and mark the point P; then step aside, and stretch from B to C, making the distance $PC = 3.14$ feet: C will be a stake on the curve.

7. Next, run out the whole chain length from C to O in the range B C. To find O D, suppose the line N C T to be drawn tangent to the curve at C. Then N D may be considered the tangential distance due to the whole chord, $= 5.95$, as above determined.

The angle $OCN = TCB = PBC$ (XVI., 4); and (5)

$ON : ND :: BC : CD \therefore ON = ND \times BC \div CD$, i.e.; $OD = ND + ON = ND + ND \times (BC \div CD) = 5.95 \times 1 + (48 \div 66) = 5.95 \times 1.727 = 10.27$.

8. The point N may be fixed otherwise by laying off $BT = CP$, and running out the chain length C N in the range C T. The point D on the curve may then be fixed by making N D equal to 5.95 feet, the tangential distance.

Next run out the chain to M, in the range C D; make M E equal to the deflection distance, 11.9 feet, and fix the point E. The points C, D, and E will be stakes 3, 4, and 5 on the curve.

9. To set the point of tangent, F, at stake 5.40, prolong the chord line D E for 40 feet to L, and suppose V E to be drawn tangent to the curve at E. Then the angle L E V is equal to the tangential angle of the curve; and the sub-tangential distance L V is to the whole tangential distance due to the 66-feet chord, as the sub-chord is to the whole chord (5); i.e., $LV = 5.95 \times 40 \div 66 = 3.6$ feet.

By the method illustrated in (6), the distance F V will be equal to $5.95 \times 40^2 \div 66^2 = 5.95 \times 0.367 = 2.18$ feet. With the distance $LF = 3.6 + 2.18 = 5.78$ feet, thus obtained, and the sub-chord $EF = 40$ feet, the point of tangent F may be established.

10. Next, set off $UE = FV = 2.18$ feet, and lay out FK in prolongation of the range UF; FK will be in the line of the terminal tangent.

11. This analysis has been somewhat minute and detailed, in order that the subject may be thoroughly understood. An instrument for measuring angles should always be used in railroad service: it greatly simplifies and abridges the labor of tracing field-curves, and gives more exact results. But occasions sometimes rise, in miscellaneous practice, when strict accuracy is not required, and the chain only can be had: the young engineer should qualify against such occasions.

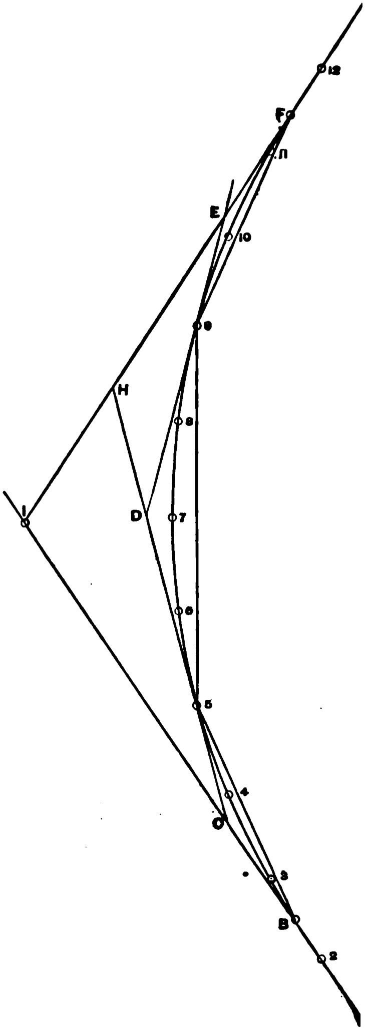
XXI.

TO TRACE A CURVE ON THE GROUND WITH TRANSIT AND 100-FEET CHAIN.

1. This, also, is best taught by an example.

Let it be a general rule, in locating, to fix the intersection of tangents, and to set the tangent points, or the P. C. at least, from the P. I. There are exceptional conditions, as a steep hillside, timber or broken ground, a very long arc, unimportance of exact conformity to the project, and the like, which warrant its omission; but where these conditions do not obtain or are not prohibitory, and a snug fit is desirable, time will usually be saved by fixing the P. I. It often proves serviceable as a reference point during construction: on the location, it gives confidence in the work and an assurance of safe progress, which are well worth a little painstaking beforehand.

2. Having established the P. I., and found the intersection angle to measure, say, 66° 45′, the first step is to find the apex distances so called, or tangent lengths IB, IF. These are each equal to $R \times tan. \frac{1}{2} I$. If a 7° 30′ curve be prescribed to *close the angle*, $R \times tan. \frac{1}{2} I = 764 \times 0.659 = 503$ feet.



Or, referring to Table XVI., the ap. dist. corresponding to 66° 45′ is found by interpolation to be 3774.6; dividing by 7.5, the rate of curvature in degrees and decimals, we have for the apex distance 503 feet, as above.

3. Before disturbing the instrument, which is presumed to stand in the range of the terminal tangent, measure I F, = 503 feet, and set the P. T. at F. Then direct the telescope to the last point fixed on the initial range A B, measure I B, = 503 feet, and set the P. C. at B. Move to B.

4. Suppose the P. C. to have fallen at a stake 2.50. In order to find the length of the curve, divide the intersection angle by the degree of curvature, having first reduced the minutes in each to hundredths of a degree by multiplying by 10 and dividing the product by 6. Thus the intersection angle becomes 66.75°, and the degree of curvature 7.5°: dividing the

former by the latter, we have 890 feet for the length of the curve.

Or, the intersection angle 66° 45′ is equivalent to 4005′, and the degree of curvature 7° 30′ is equivalent to 450′: dividing the former by the latter, we have 890 feet for the length of the curve, as before.

5. Adding 8.90 to 2.50, the number of the P. C., the P. T. is found to fall at stake 11.40. Let the rear chainman make a note of this, that there may be no mistake in the terminal *plus*.

6. Next, to determine the proper deflections from the line of tangent at B, bear in mind that the deflection for a whole chain is *half the degree of curvature;* and that, in field-curves of more than 300 feet radius, the deflections for sub-chords, or *plusses*, may, without material error, be held to vary directly as the sub-chords themselves; that is to say, the sub-deflections due to 30, 60, and 80 feet, for instance, will be, to the deflection due to 100 feet, as 30, 60, and 80 are to 100.

7. Thus, in the example, 7° 30′ being the degree of curvature, one-half of this, or 3° 45′, will be the deflection due to a chord of 100 feet; and $\frac{50}{100}$ of this, or a deflection of 1° 52½′ from the line of tangent at B, will fix stake 3, 50 feet distant on the curve.

8. The following is a simple rule for finding sub-deflections: —

Multiply the sub-chord in feet by the rate of curvature in degrees and decimals: three-tenths of the product will be the sub-deflection in minutes.

Thus, in the example, $50 \times 7.5 = 375$, and $375 \times 0.3 = 112.5' = 1° 52\frac{1}{2}'$, as before.

9. Having set stake 3, stakes 4 and 5 will be fixed by successive deflections of 3° 45′. In establishing stake 5, the index will read, $1° 52\frac{1}{2}' + 3° 45' + 3° 45' = 9° 22\frac{1}{2}'$ = angle C B 5.

10. Suppose the instrument moved to 5. See that the vernier has not been disturbed, backsight to B, and deflect 9° 22½′ right; i.e., double the index angle. The index will now read, 18° 45′ = the angle I C D; and the telescope will be directed along the line C D, tangent to the curve at 5, for the reason that the angle B 5 C has been made equal to the angle C B 5 (XVI. 4).

Proceed with successive deflections of 3° 45′ from this tangent, and set stakes 6, 7, 8, and 9, at intervals of 100 feet.

11. Suppose the instrument moved to 9. In fixing this

stake, the index will read, 18° 45′ + 4 times the constant angle 3° 45′, = 18° 45′ + 15° = angle I C D + angle D 5 9, = 33° 45′. In order to place the telescope in the line D E, tangent to the curve at 9, it is now necessary to turn an angle to the right, from backsight to 5, equal to D 9 5 = D 5 9 = 15°; i.e., the vernier should be moved from 33° 45′ to 33° 45′ + 15° = 48° 45′. The telescope will then be in tangent at 9.

12. A simple rule for finding the index angle which shall place the telescope in tangent at any point on the curve is as follows: —

From double the index angle which fixed the given point, subtract the index reading in tangent at the last turning-point: the remainder will be the required index angle.

Thus the index angle which established stake 9 was 33° 45′. Double this angle will be 67° 30′; subtracting 18° 45′, the reading in tangent at the last turning-point, we have 48° 45′, the required index angle, as before.

The reasons for the rule will be obvious from an examination of the figure.

13. Being in tangent, then, at 9, and the index reading 48° 45′, a deflection of 3° 45′ will fix 10: a further deflection of 3° 45′ will fix 11, and the index will stand at 48° 45′ + 7° 30′ = 56° 15′.

14. To find the deflection corresponding to the sub-chord 11 F, = 40 feet: by the foregoing rule (8), the degree of curvature, 7.5, multiplied by 40, the length of the sub-chord in feet, gives a product of 300, three-tenths of which amount to 90 minutes = 1° 30′. Adding 1° 30′ to 56° 15′, makes the index angle 57° 45′ to fix the P. T. at 11.40.

15. Move to the P. T. at 11.40, see that the vernier has not been disturbed, and backsight to 9. By the foregoing rule (12), double the index angle, 57° 45′, less the angle in tangent at 9, the last turning-point, 48° 45′, = 115° 30′ — 48° 45′, = 66° 45′, = the index angle in tangent at the P. T., = the total angle consumed by the curve. The work thus proves itself.

16. The preceding example would appear in the field-book as follows: —

STA.	DIST.	DEF.	INDEX.	TANG.	COURSE.	M. C.	REMARKS.
2.	50	..	..	..	..	..	
2.50 ⊙	50	1° 52½′ R.	1° 52½′ R.	..	..	..	2.50 P. C. } 7° 30′ Curve Right 66° 45′.
3.	100	3° 45 ′	5° 37½′	..	..	..	11.40 P. T. }
4.	..	3° 45 ′	9° 22½′	..	..	..	Apex Dist. 503 feet; P. I. set.
5. ⊙	..	3° 45 ′	22° 30 ′	18° 45′	..	..	
6.	..	3° 45 ′	26° 15 ′	..	..	..	
7.	..	3° 45 ′	30° 00 ′	..	..	..	
8.	..	3° 45 ′	33° 45 ′	..	..	..	
9. ⊙	..	3° 45 ′	52° 30 ′	48° 45′	..	..	
10.	..	3° 45 ′	56° 15 ′	..	..	..	
11.	40	1° 30 ′	57° 45 ′	..	..	..	
11.40 ⊙	60	..	..	66° 45′	N. 15° 00′ E.	N. 15° 10′ E.	
12.	..	..	..	..	..	..	

17. This mode of running curves secures a record of each step in the proceeding; so that, if any error occurs, it can readily be detected. At each turning-point, the number in the "*tangent*" column must correspond with the central angle due to the length of curve to that point; and at the P. T. that number must correspond with the total central angle. The work can thus be checked with facility during its progress, and checks itself at the end.

18. The young transitman is recommended to rule blanks after the pattern given, and exercise himself thoroughly in computing the parts, and recording the field-notes of various curves assumed at will: drawings are not necessary.

19. Another method, and in some respects a better one, is, before starting on a curve, or during its progress, to record for all its stations the deflections which would locate them if the instrument remained at the P. C. Obviously the final deflection thus recorded would be half the central angle of the whole curve; and, if the instrument were placed anywhere on the curve, a B. S. to P. C. and deflection of half that central angle would locate the P. T. The same reasoning will apply to any subdivisions of the curve which may be found convenient in field work, the deflection angles for plusses being reckoned from the P. C. and recorded as in the case of whole stations. I am indebted to Mr. Robert Burgess, C.E., for recommending this method. Following is his illustration of it as applied to the preceding example. This illustration serves also to exemplify another form for field-notes.

STA.		DEF. ANGLE.	TOTAL ANGLE.	CALC. CURVE.	MAG. CURVE.	REMARKS.
12	° ′	° ′	° ′	°	° ′	
+ 40	× P.T.	33 22½	66 45	N: 15 E.	N. 15 10 E.	
11		31 52½				Apex Dis. 503 ft. P. I. set.
10		28 07½				
9	×	24 22½				
8		20 37½				
7		16 52½				
6		13 07½				
5	×	9 22½				
4		5 37½				
3		1 52½				
+ 50	× P.C. 7 30 R.	0 0				
2						

20. The transitman, at P. C., Sta. 2 + 50, sets his vernier at zero, takes his B. S. and locates the stations in order to 5, where a point is given. He then moves to 5, sets vernier at

zero and backsights to P. C. A deflection of 9° 22½′ will now place him in tangent; a deflection of 13° 07½′ will locate Sta. 6, and so on, using the recorded angles. Suppose a tree to mask the site of Sta. 8. Placing a stake as near thereto as possible, to hold distance; go on deflecting to 9, the vernier reading 24° 22½′, where another point is given. Moving now to 9, the transitman observes the general rule, applicable to this method, namely, *to set his vernier at each new instrument point, to the angle recorded opposite the point of his proposed backsight.* In this case that point is Sta. 5. He therefore sets the vernier at 9° 22½′, backsights to 5, and turns to 20° 37½′ to locate 8. The vernier at 24° 22½′ would put him in tangent, and the successive recorded deflections complete the curve. The transit is then moved to P. T., the vernier set at 24° 22½′, the recorded angle opposite last point at 9, according to the above rule, backsight taken on that point, and a final deflection to 33° 22½′ turns off the tangent ahead.

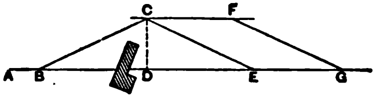
21. The chief advantages of this method are the completeness of the record for subsequent use; its adaptation to a retracing of the line backward as well as forward, which please observe particularly; the little labor it imposes in mental arithmetic; and its simplicity, permitting any one who can read figures and turn an angle to relieve the transit on occasion.

The writer was raised on the first method; is still partial to it, out of a certain loyal feeling to the elder generation from whom it descended to him; but it must be owned the children, in some things, have surpassed the fathers,—as needs they should, else were there no progress,—and this seems to be one of those things.

XXII.

TURNING OBSTACLES TO VISION IN TANGENT.

1. Draw C F parallel to A B. Let lines B C, C E, F G, cut these parallels at equal inclinations. Call this angle I. Then B C = C E = F G. B E = B D + D E = 2 B D. But B D = B C *cos.* I, ∴ B E = 2 B C *cos.* I. E G = C F. B G = E G + B E = C F + 2 B C *cos.* I.



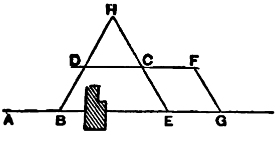
Example.

Suppose B to be a stake 24.50 on the tangent A B, and that a deflection left of 10° be made there for 200 feet to a point C. Set transit at C, vernier reading 10° left. B S to B, and deflect 20° right. Vernier will now read 10° right, and telescope will be in line C E. Make C E = 200 feet. Move to E. See that vernier still reads 10° right. B S to C, and turn 10° left. Vernier will now read zero, and telescope will be in line E G, or tangent A B prolonged.

Distance B E = 2 B C *cos.* I = 2 (200 *cos.* 10°) = 400 × .985 = 394 feet. Then E = 24.50 + 394, = stake 28.44 on tangent A B prolonged.

If a parallel line C F were run, a deflection of 10° right would be made at each of the points C and F. If C F were 250 feet, then B G would be = 250 + 394 = 644 feet, and the point G would fall at stake 30.94 on tangent A B prolonged.

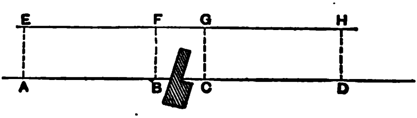
2. If angle I = 60°, the other conditions of above method being observed, triangle B H E will be equilateral, and B E = B H = H E. If the parallel D C or D F be run, B E = B D + D C, and B G = B D + D F. For field work see last example.



3. In turning obstacles by either of these methods, the angles should be measured with extreme niceness. Handle the instrument lightly, to avoid jarring the vernier; and, if possible, observe well-defined distant objects in the several short ranges, that the lines of foresight and backsight may accurately coincide.

In locating, the following method is preferable to those given above, and should always be used on long tangents.

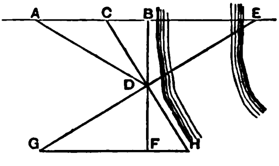
4. Having established points A and B on the centre line, the farther apart the better within limits of distinct vision, set off the equal rectangular distances AE, BF, ranging clear of the obstacle. Place the transit at E or F, fix points G and H on the forward range, and, rectangularly to these points, establish others on the forward range of the centre line at C and D. The offset distances should be measured very carefully with the rod, or with a steel tape if they exceed in length the pocket rule which every engineer should have about him.



XXIII.

TURNING OBSTACLES TO MEASUREMENT IN TANGENT.

1. Fix a point on tangent AB prolonged at E. Lay off at B a perpendicular of any convenient length. Move the instrument to D, make the angle BDA = BDE, and mark the point of intersection A. By reason of symmetry in the triangles ADB, BDE, AB = BE, and may be measured on the ground.



2. Or, fix the point E, and lay off the perpendicular BD as before. Move to D, direct the telescope to E, turn a right angle EDC, mark the point of intersection C, and measure CB. Then, by reason of similarity in the triangles CBD, DBE, CB : BD :: BD : BE, $\therefore BE = BD^2 \div BC$.

Example.

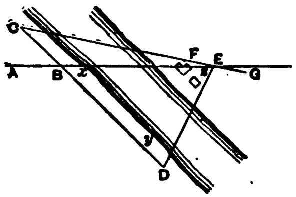
Suppose BD to be 60 feet, and BC 40 feet. Then $BD^2 \div BC = 3600 \div 40 = 90$ feet = BE.

3. Or, with the instrument at D, measure the angle BDE. *Then* $BE = BD \tan. BDE$.

Example.

B D = 120 feet, angle B D E = 54° 40′. B D *tan.* B D E = 120 × 1.41 = 169.2 feet = B E.

4. Or, without an instrument, lay off any convenient lines B F or C H. Mark the middle point D. Line out H G, parallel to A B. Mark on it the point G in range with D and E. Then G F = B E, or G H = C E.



5. Should the use of a right angle be inconvenient, turn any angle E B D = x, measure B D about equal by estimation to B E, if the ground permits, and set a point D. Move to D, and measure angle B D E = y.

Then the angle B E D, or z, = 180 — ($x + y$), and, by trigonometry, *sin.* z : *sin.* y :: B D : B E, ∴ B E = B D *sin.* y ÷ *sin.* z.

Example.

Let $x = 44° \; 02'$, $y = 71° \; 48'$, B D = 300 feet.

Then $z = 180° - (x + y) = 180° - (44° \; 02' + 71° \; 48') = 180° - 115° \; 50' = 64° \; 10'$. B E = B D *sin.* y ÷ *sin.* z = 300 *sin.* 71° 48′ ÷ *sin.* 64° 10′ = 300 × .95 ÷ .90 = 316.6 feet.

The calculation by logarithms would be as follows: —

Log. 300	2.477121
Log. sin. 71° 48′	9.977711
Sum	12.454832
Log. sin. 64° 10′	9.954274
Log. 316.6. Diff.	2.500558

If E is invisible from B, extend the line D B towards C, until a line C E clears the obstacle. The point E must then be established by intersection of the sides C E, D E, in triangle C D E. Supposing the extension B C to have been 120 feet, the side C D will be 420 feet, the angle y 71° 48′; and, by a calculation similar to the above, the side D E, opposite angle x in the lesser triangle, identical with D E in the larger one, will be found to be 231.7 feet. The sum of the angles at the base *C E of the triangle* C D E = $180° - y = 180° - 71° \; 48' = 108° \; 12'$. *By trigonometry*, two sides and the included angle be known in any plane triangle, the sum of the known sides is to their difference as the tangent of the half sum of angles at base is to the tangent of half their difference. In triangle C D E, therefore, C D + D E or 651.7 : C D — D E or 188.3 :: *tan.* 108.12 ÷ 2 or *tan.* 54° 06′ : *tan.* 54° 06′ × 188.3 ÷ 651.7 = .399 = *tan.* 21° 45′, = half the difference of the angles at the base.

Log. 188.3.	2.274850
Tan. 54° 06′	0.140334
Sum	2.415184
Log. 651.7	2.814048
Tan. 21° 45′. Diff.	9.601136

The angle at C, being evidently the lesser of the two angles at the base, is equal to the half sum of these angles decreased by their half difference, = 54° 06′ — 21° 45′ = 32° 21′.

Set the transit, then, at C, foresight to D, deflect 32° 21′ left, and fix in that range two points F and G, between which a cord may be stretched, and as nearly as can be judged on opposite sides of E. Move to D, foresight to C, deflect 71° 48′ right, and establish a point E at intersection with F G. Cross to E, B S to D, and deflect the angle $z = 64°\ 10'$ into the line of the tangent A B prolonged.

SUGGESTIONS AS TO FIELD-WORK AND LOCATION-PROJECTS.

XXIV.–XXV.

SUGGESTIONS AS TO FIELD-WORK AND LOCATION-PROJECTS.

XXIV.

SUGGESTIONS CONCERNING FIELD-WORK.

1. **The Chief Engineer**, after conference with his employers in regard to the character of the work contemplated, and its general route, should, before organizing field-corps, go over the ground in both directions, and, aided by the best attainable maps, qualify himself by actual observation to instruct his assistants as to the conduct of the survey. Equipped with hand-level, pocket-compass, and in rough regions with the aneroid, he can often not only prescribe lines for examination, but indicate the gradients to be tried, thus saving a vast amount of random labor and needless expense. Such thorough preliminary exploration is due both to himself and his principals: it is too often omitted, or done with a perfunctory rush. In broken topography, no maps, notes, or information derived from others can supply the want of personal acquaintance with the ground itself. He must indispensably make that acquaintance, in order to project an intelligent location, — a work which should rarely be delegated; being capital service, it comes within the special function of the chief engineer, and only the necessary distribution of labor attending a great charge should relieve him from its direct performance.

2. A **Field-Corps** in settled regions generally consists of one senior assistant or chief of corps, one transitman, one leveller, one rodman, two chainmen, one slopeman, and two or more axemen.

The following notes in regard to the allotment of duties and the conduct of work may be acceptable. They are copied from the writer's memoranda for the guidance of his field-parties, with the addition of some detail, and practical hints here *and there, to* aid the inexperienced.

3. THE SENIOR ASSISTANT will receive instructions from the principal assistant in charge, or the chief engineer, and will act exclusively under his direction.

He will be held responsible for the good conduct of the corps, and for the rapid, exact, and economical performance of the work. Indecent or blasphemous outcries in the field should be prohibited. The writer's various travel by land and sea has brought him acquainted with many cultivated, estimable, energetic, profane fellows, but not one in whom swearing was a grace; nor has he ever seen an instance where it forwarded work. Those considerate of others' pride and self-respect will generally find that a good leader makes good followers.

The senior assistant is empowered to appoint and dismiss employes below the rank of rodman, and will report any inefficiency or neglect of duty in the ranks above to his chief.

He will pay the authorized expenses of the corps for supplies, repairs, transportation, and subsistence, taking duplicate vouchers. Accommodations should be sought near the work. When not thus obtainable, transportation to and from the field is to be regarded as a measure of economy for the company, compensating the expense incurred by saving time and labor.

He will superintend field operations in person, keeping in advance of the transit to direct and expedite the work, and establish the turning-points. On preliminary surveys, the axe should be little used; and on alternative locations, or such as may be subject to revision, trees over four inches in diameter need rarely be felled.

He should be patient with sensitive landholders. He will find exercise for that amiable virtue, also, with the field visitors who so often spare time from useful toil to tell him he is on the wrong line, and to show him where the right one is.

Note for record the kind and quality of material to be moved, observing quarries, wells, or other indications for the purpose; the timber and rock in the country traversed, with a view to their use in construction, and the widths of passage to be provided for streams, together with the character of their banks and beds.

Note the names of residents in the immediate vicinity of the work on survey; and, on location, cause the property-lines to be observed and recorded also when convenient.

Always begin grade-lines at the summit, and work down. For such service, carry habitually a slip of profile paper, say six inches wide and two feet long. Rule the proposed grade-line on it, assume a summit cut, mark the stations, and start down. When at fault, the elevation can be spotted on the profile, which will show at a glance, without any calculation, how you stand in relation to grade.

The work of each day should be compiled and recorded in the evening, that no delay may result from the loss or defacement of a field-book.

FORM FOR SURVEY RECORD.

Sta.	Dis.	Deflec.	Course	M. C.	Eleva.	Slope.	Remarks.

FORM FOR LOCATION RECORD.

Station.	Distance.	Course.	Mag. Course.	Elevation.	Gradient.	Grade.	Variation.	Slope.	Remarks.

On location, check the transitman's calculation of the length of each curve and the fractional deflections.

The senior assistant must be qualified to locate a line accurately on the ground from the project furnished him. Lateral deviations exceeding five feet on ten-degree slopes, three feet on fifteen-degree slopes, and two feet on twenty-degree slopes, will be considered errors requiring correction. Measurements to the experimental line should be made and noted frequently, in order not only to check the field-work, but that the line may by means of them be laid down on the map.

The senior assistant will supply himself with drawing instruments, colors, brushes, and the like personal furniture of an engineer. He will take care also that the stationery, field-books, instruments, and other articles of outfit supplied by the company, are not misused. His field equipment should always include a hand-level and a pocket-compass: to these may be added a straight, round staff, five or six feet long, steel pointed; it will be found exceedingly useful.

If without a topographer, he should make sketches of irregular ground, of streams, buildings, roads, and the like, to help in compiling the map.

In hilly or wooded districts, the front chainman carries the flag on survey, and is at the head of the line. In open, plain country, work is greatly forwarded by detaching an axeman with flag, to accompany the senior in advance, and set turning-points for the transit. The transitman follows as rapidly as possible, and the chainmen come after, lining in their stakes by the eye from point to point. The whole force is thus kept pretty steadily in motion.

On wide plains, a set of chain-pins may be used, and survey-stakes placed five hundred or a thousand feet asunder. Very often stakes at intervals of two hundred feet are sufficient, the levels being taken every hundred. Location stakes are put in every hundred feet.

4. THE TRANSITMAN will be expected to keep his instrument in adjustment, and to be quick and accurate in its manipulation. It is not needful to plant it as if for eternity. On the contrary, it should be set gently, the legs thrust but slightly into the ground, and the screws worked without straining.

On long tangents it is a good plan to reverse the instrument at each new point, putting the north and south ends forward alternately. Small errors in adjustment are thus balanced in some measure. Select also, in such a case, some distant object in range, when practicable, to run by. The telescope, in wind or sun, will sometimes warp a little out of line.

Never omit to note both the calculated and magnetic bearings of the lines on survey, and of the tangents on location. Guard against the error of reading deflections or bearings from the wrong ten mark; as, for instance, 34 instead of 26.

At the beginning of a curve, let the rear chainman know the plus of the P. T. Tell the front chainman the degree of curve, and instruct him how, by multiplying 1.75 by the degree, he can find the distance of each full station from the range of the last two. A quick fellow will soon pick this up, and become wonderfully skilful in practice. Thus accomplished, he is a check on wrong deflections.

In running curves, a tangential angle of fifteen degrees from *one point should* seldom be exceeded: twenty degrees is to be *regarded as a maximum.*

Carry a pocket-compass, and observe with it the magnetic bearings of streams and roads crossed.

Record daily each day's run; fill out the distance column, transcribe the chain-book, and, on location, record the apex distances also in the column of remarks.

On survey, do not erase from the field-book the notes of abandoned lines. Simply cancel, and mark them "abandoned," in such manner that they may still be legible.

When required by the senior assistant, the transitman will aid in the making of maps.

5. The Leveller must be familiar with the adjustments of his instrument, keep it in order, and handle it rapidly.

On survey, establish and mark benches at half-mile intervals; on location, four to the mile when practicable.

Note the surface elevations, the depths, and the flood heights, of all considerable streams crossed. Take elevations in the beds of small streams.

Six hundred feet each way should be regarded as the maximum sweep of the level.

Carry a hand-level, and thus save the time required to peg across narrow hollows, or over heights which can be turned with the instrument.

The leveller should record his work, and make up the profile daily.

6. The Rodman will give his intermediates close by the stations, observing the number of each one as a check on the chainmen, and calling it out to the leveller. He should have an eye to abrupt irregularities in the ground, and give plus elevations when necessary.

He will keep note of bench-marks and turning-pegs, describing the latter occasionally with reference to the nearest stake, that the levels may be taken up speedily in case of a revision of the line.

When unaccompanied by an axeman, the rodman is equipped with belt and hatchet. Sometimes he is furnished also with a steel pin for turning on. The pin has a ring through the head, by which it may be hung to a spring hook in the belt.

The rodman will assist the leveller at record and profiles, and transcribe the slope-book daily.

If stakes of survey are set at intervals of two hundred feet, give rods every hundred feet, as nearly as the midway points can be guessed.

7. **The Slopeman** will give backsights, and take the cross slopes for one hundred feet on each side of the line at every station.

8. **The Rear Chainman** will carry a book in which to note the turning-points, the crossings of roads, streams, swamps, woodland, and, when convenient, property lines also. He will hand it in daily to the transitman for record. As each successive chain is stretched, the rear chainman calls out the number of the stake it is stretched from: this assures the selection of the right number for the stake ahead.

9. **One Axeman** will be detailed to make stakes, another to mark and drive them. Additional axemen may be employed at the discretion of the senior assistant, as the work requires them. Wanton destruction of timber, fences, growing crops, or other property, should not be allowed. Axemen must be careful, in passing through the country, to do as little damage as possible.

XXV.

THE CURVE-PROTRACTOR, AND THE PROJECTING OF LOCATIONS.

1. The curve-protractor is simply an eight-inch, semi-circular horn protractor, upon which a series of twenty-three curves, from half a degree up to eight degrees, is finely engraved, to a scale of 400 feet to an inch. After some years' use in his own practice, the contrivance was transmitted by the writer to the well-known firm of James W. Queen & Co., mathematical-instrument makers, New York and Philadelphia, by whom it is now manufactured. It greatly facilitates the projecting of lines and solution of field-problems on location. It enables the engineer, for example, by a short, graphical process and rapid inspection, to find the curve which shall close an angle between tangents, or terminate a compound curve, and pass at the same time through some fixed intermediate point, without liability to the errors, and free from the loss of time, involved in a tedious calculation. Other applications, such as the nice adjustment of line among buildings, on precipitous steeps, and the like, will suggest themselves to the experienced reader.

2. For office use, the writer prefers a home-made curve-protractor of mica, prepared as follows: Take a thin, clear sheet, say six by ten inches, free from bubbles and cracks. Block it securely on the drawing-table with thumb-tacks, setting the shanks close against the edge of the sheet, but not piercing it, and the heads lapping its edge. From a centre, midway of one of the long sides and near its margin, strike the curves from 12° or less, varying outwards by half-degrees to 6°; thence by quarter-degrees to 4°; and thence by ten-minute differences to 2¼°. This covers one side of the sheet, the scale being 400 feet to an inch. Now release the sheet, turn it over, and on its other face strike the remaining curves, down to ten minutes, from centres on the table, in the reverse direction, so that they shall cross the first series at a large angle. Space them about three-eighths of an inch asunder at the middle. Use a needle-point centre for the first series, to avoid boring a large hole in the sheet. Add also, on that face, two radial lines drawn towards the corners. Score the fractional curves very lightly, the full figure curves a little deeper, but all of them with steadiness and delicate stress. Practise beforehand on a separate slip, for the right intensity of stroke. Engrave the numbers with a stiff steel point on the opposite side of the sheet to that upon which the corresponding curve is traced. Bring the work out by rubbing it with India ink. If preferred, the flat curves on the reverse side may be colored with carmine. Duplicate protractors will be found useful in projecting compound curves. Clip off the four corners, re-enforce the edges with a narrow ribbon of tracing-linen, folded over them and glued fast, and the article is complete. It is perfect for its use; durable, flexible, spotlessly transparent, not liable to warp or change dimensions with changes in the temperature or moisture of the air, and, withal, takes and preserves a visible line, thin as the gossamer.

3. To experienced locating engineers, the curve-protractor needs no wordy commendation. Contrasted with the inconvenient appliances of the old method, — cardboard, veneer, glass, or dividers, — its advantages will be manifest. A few hints as to the manner of using it may be in place.

4. First of all, let the experimental line approximate to the probable line of location; and, upon that base, construct a contour map, with reference to which special observations should be made in the field, and the chaining done with care.

Extreme accuracy in the contours need not be attempted. Note the courses of streams, ravines, and ridges, the average slopes at frequent intervals, and, on irregular ground, make illustrative sketches to aid in utilizing the other notes. Practice gradually teaches how to observe critical points intelligently, and to record them briefly. In valleys or plains, where the location indicated is made up of long tangents and easy curves, little detail is required; but on bluffy, tortuous ground, with unavoidable divides to overcome, and long reaches of maximum gradient to be fitted, the method by contours is not only the simplest and clearest way of compiling necessary information, but is an aid to the engineer in projecting the right line, which no substitute can fully replace.

5. The writer is forced by the strong constraint of experience to differ on this subject with Mr. Trautwine. The difference, however, is a permissible one, and implies no lack of grateful respect for that veteran engineer, whose books are our handy-books, and to whose genius we are all debtors.

6. Having made the map, with ten-foot contours, suppose, for example, that a continuous gradient five miles long is to be located. Spread the dividers to 500 feet by the scale, start at the foot of the ascent, and step up, complying with the general trend of the ground, to the summit. This needful preliminary gives about the distance you have to work on, which cannot in many cases be derived from the experimental line directly. The profile furnishes the height to be overcome; and you are thus prepared to assume a summit cut, and determine the gradient. Having adopted one, say, of 66 feet per mile, observe that this rises five feet in 400 feet. Spread the dividers, then, to 400 feet by scale, and stand one leg on or near the summit, at a point corresponding to a five or ten unit in the elevation of the gradient. That is to say, if the grade elevation at the summit be 362, for instance, stand the leg of the dividers a little beyond or a little short of the summit, at a point where the grade elevation is 365 or 360. Thence, exercising good judgment to conform in a general way to what the location ought to be, and to make no angular indirections which cannot be closed with the maximum curvature, step forward down the incline. Name each step mentally as it is made, 355, 350, 345, 340, &c., and spot at the same time with a pencil-point the contour or half space, directly opposite, correspond-

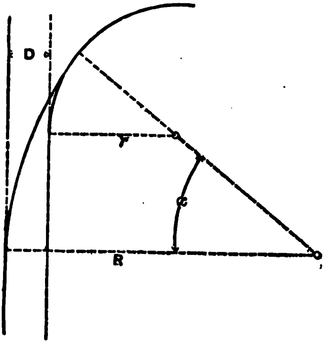
ing to it in elevation. Connect the pencil-marks with a faint dotted line.

7. Were the ground a straight, regular hillside, the steps would be made directly from contour to half-space, thence to the next contour below, and the dotted line would mark out a tangent conforming exactly to the ground surface. On devious slopes, rounding within the limit of the sharpest permissible curve, the same exact conformity could be obtained, if desired, and a grade-line laid down which should require the least possible expense in building. On irregular, winding ground, an approximation only to the dotted line can be made: it is nevertheless a guide to go by; and, the more nearly the location project approaches it, the lighter will the work of construction be. The dotted line, in short, is analogous to a profile; and the engineer can prescribe his cuts and fills with reference to it, by means of curve or tangent, just as on the profile he does the same by means of grade-lines. A fairly correct map will enable him to construct a profile from the project, and to amend its errors without the trouble and expense of tentative field-work. The writer's habitual practice has been to base his preliminary estimates on a profile thus deduced from the map; and he recommends the practice to others. They will be surprised to observe the likeness between such a profile, tolerably well done, and that of the subsequent location.

8. It is a good custom, and one which cannot prudently be neglected where long reaches of maximum gradient are encountered, to "slacken grade" on the curves. In making this adjustment, the contour map is exceedingly useful. An approximate project is first required, in order to determine the curvature, and, from that, the varying gradient. The location can then be laid down on the map with satisfactory precision. Opinions differ as to the right allowance per degree of curvature, and no experiments seem to have been made from which to deduce an authoritative rule. Some say 0.025 per degree per 100 feet; others, 0.05; others, variously between the two. Probably 0.05 is the safer rate. This amounts to 2.64 feet on a mile of continuous one-degree curve, and makes a nine-degree curve, about the curve of double resistance at ordinary passenger speeds.

9. In projecting locations, the better way generally is to strike the curves first.

10. The following tables may be of assistance. It was needful, calculating them at all, to calculate them right; but of course such exactness as the figures would seem to indicate is unattainable in practice.

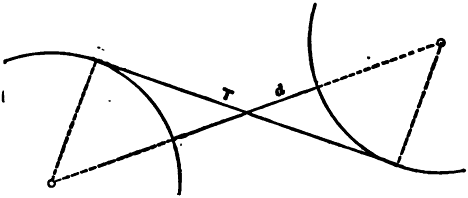


11. TABLE SHOWING THE DISTANCE, D, IN FEET, AT WHICH A STRAIGHT LINE MUST PASS FROM THE NEAREST POINT OF ANY CURVE, STRUCK WITH RADIUS r, IN ORDER THAT A TERMINAL BRANCH HAVING RADIUS $R = 2\,r$, AND CONSUMING A GIVEN ANGLE, x, MAY MERGE IN SAID STRAIGHT LINE.

$$D = (R - r) \times (1 - \cos.\ x).$$

Angle x.	Degree of the Main Curve.								
	2°	3°	4°	5°	6°	7°	8°	9°	10°
	D.								
2°	1.72	1.15	0.86	0.69	0.57	0.49	0.43	0.38	0.34
3°	4.01	2.67	2.00	1.60	1.34	1.15	1.00	0.89	0.80
4°	6.88	4.58	3.44	2.75	2.29	1.96	1.72	1.53	1.37
5°	10.89	7.29	5.44	4.35	3.63	3.11	2.72	2.42	2.18
6°	15.76	10.50	7.88	6.30	5.25	4.50	3.94	3.50	3.15
7°	21.49	14.32	10.74	8.59	7.16	6.14	5.37	4.77	4.30
8°	28.36	18.91	14.18	11.35	9.45	8.10	7.09	6.30	5.67
9°	35.24	23.49	17.62	14.09	11.75	10.07	8.81	7.83	7.05
10°	43.55	29.13	21.77	17.42	14.52	12.44	10.89	9.68	8.71

If $R = 1\frac{1}{2} r$, use half the tabular distance; if $R = 3 r$, use twice the tabular distance; if $R = 4 r$, use three times the tabular distance, and so on.



12. TABLE SHOWING THE DISTANCE, d, IN FEET, AT WHICH CURVES OF CONTRARY FLEXURE MUST BE PLACED ASUNDER IN ORDER THAT THE CONNECTING TANGENT, T, MAY BE 300 FEET LONG.

DEGREE OF CURVE.	DEGREE OF CURVE.										DEGREE OF CURVE.
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	
	d.										
1°	3.9	5.24	5.92	6.29	6.35	6.68	6.86	7.00	7.08	7.18	1°
2°	..	7.84	9.43	10.38	11.20	11.70	12.20	12.55	12.80	13.06	2°
3°	..	..	11.77	13.43	14.64	15.68	16.45	17.09	17.61	18.05	3°
4°	..	..	..	15.65	17.39	18.76	19.90	20.82	21.64	22.31	4°
5°	..	..	..	..	19.54	21.22	22.76	24.01	25.07	25.97	5°
6°	..	..	..	..	..	23.32	25.20	26.70	28.00	29.13	6°
7°	..	..	..	..	..	..	27.25	29.01	30.58	31.93	7°
8°	..	..	..	..	..	..	..	31.05	32.82	34.41	8°
9°	..	..	..	..	..	..	..	..	34.82	36.31	9°
10°	..	..	..	..	..	..	..	..	..	38.56	10.

Examples.

A 7° and 4° should be 19.9 feet asunder; a 5° and 9° should be 25.07 feet asunder.

As approximations, for a connecting tangent 400 feet long, take twice the tabular distance: for a connecting tangent 200 feet long, take half the tabular distance.

It is thought by some that the parabola is an ideal curve for railroads, and should be adopted; by others, that a spiral or parabolic "easement," so called, is sufficient by way of transitional flexure from straight line to circular curve; by others, that a circular curve compounded with similar terminal curves of larger radii is to be preferred; by others, that the circular curve alone serves all conditions best. The writer holds with the last party up to curves of about 4°, and for sharper ones, in the absence of proof to the contrary, believes with the third party that circular terminal curves, not less than 200 feet long, having half the degree of the main curve, are likeliest to meet, in a fair measure, the requirements of actual service.

Meanwhile the old circular curve continues to do good work. On well-regulated lines a curve is usually indicated to the traveller by the inclination of the car only; there is no jar. Some years ago one of the most intelligent, experienced, and enterprising railroad managements in this country caused a thorough practical test to be made of the second device above mentioned, with a view to its adoption if found advisable. The engineers and superintendents who made the test reported adversely, on experimental grounds. The proposed improvement was not adopted.

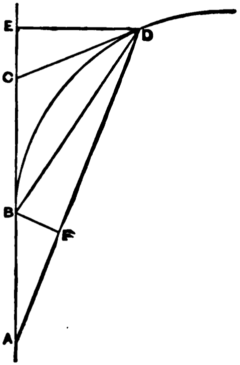
PROBLEMS IN FIELD LOCATION.

XXVI.–XXXVII.

PROBLEMS IN FIELD LOCATION.

XXVI.

HOW TO PROCEED WHEN THE P. C. IS INACCESSIBLE.



1. Suppose, for example, a projected 5° curve, beginning at stake 24.20, or B in the diagram.

First Method. — At any point A, which we will assume to be stake 23.40, set up the transit. Let it be judged that stake 27, marked D in the diagram, must fall on accessible ground. Then the distance B D, around the curve, is 280 feet, corresponding to an angle E B D of 7° at the circumference, or an angle of 14° at the centre. The chord of a 1° curve consuming this angle, by Table XVI., is 1,396.6 feet; that of a 5° curve, B D in the figure, is one-fifth of this, or 279.3 feet. In the triangle A B D are thus known the sides A B, B D, and the sum of the angles at A and D, which sum is equal to the angle E B D.

Hence, by trigonometry, —

As the sum of the sides given	= 359.3 A C	7.444543
Is to their difference	= 199.3	2.299507
So is tan. ½ sum of angles at base	= 3° 30′	8.786486
To tan. ½ their difference	= 1° 56½′ . . .	8.530536

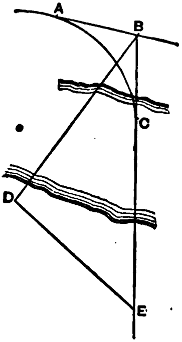
Adding half the difference to half the sum, the larger angle, A, is found to be 5° 26½′; subtracting half the difference from half the sum, the smaller angle, D, is found to be 1° 33½′. The length of the side A D may be found in like manner by trigonometrical proportion; or, perhaps more simply, thus: —

$$BD \times \textit{nat. cos.}\ D = DF = 279.2.$$
$$BA \times \textit{nat. cos.}\ A = AF = 79.6.$$
$$AF + FD = AD = 358.8.$$

We are now prepared, from our point A, to deflect the angle 5° 26¼′ R, and lay out the line A D to the point D on the curve. Moving the instrument to that point, and backsighting to A, a deflection of 1° 33½′ R places the telescope on line D B; a further deflection of 7° places it in tangent at D, and the curve may thence be traced in both directions.

2. Second Method. — Having, as in the first method, judged that stake 27, marked D, must fall on accessible ground, and thus determined the central angle subtended by the arc B D, refer to Table XVI. for the ap. dist. of a 1° curve, corresponding to 14°, the given angle: It proves to be 703.5 feet. One-fifth of this, 140.7 feet, is the tangent or apex distance, B C, of a 5° curve, which may be measured on the ground. Moving the instrument to C, turning 14° R, and laying off the line C D = B C, the point D on the curve is ascertained.

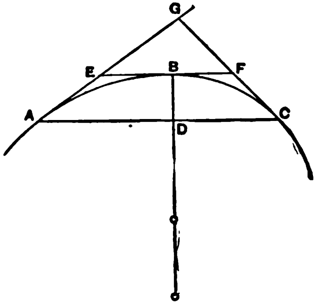
3. The preceding methods are manifestly applicable to the ends also of curves, as well as the beginnings. A case not unfrequent in practice may be added in conclusion of the subject.



Suppose a 2° curve terminating at C, in marsh or stream not measurable directly. Let C fall at stake 32.20. At any convenient point A, say stake 29, place the transit with telescope in tangent. The arc A C, = 320 feet, includes an angle of 6° 24′. The ap. dist. of a 1° curve corresponding to this angle in Table XVI. is 320.34 feet; that of a 2° curve is therefore 160.2 = A B. Move to B, deflect 6° 24′ R into the range of the terminal tangent, and fix E on the opposite shore. Fix also D, and note the angle E B D. Move to E. Measure the angle D E B, and the distance D E. The triangle B E D may then be solved. If B E is found to be 670 *feet,* $CE = 670 - 160.2 = 509.8$, and stake E = 32.20 + 509.8, = *say 37.30.*

XXVII.

HOW TO PROCEED WHEN THE P. C. C. IS INACCESSIBLE.



1. Suppose a 4° curve, A B, compounding at B into a 6° curve B C.

First Method. — Place the transit at any point A, say stake 34. Let the proposed P. C. C. fall at stake 36.25. Assume that we wish to reach C, on the second curve, by means of the straight line A D C. The arc A B, covering 225 feet of a 4° curve, subtends an angle of 9°. A D is half the chord of twice this angle.

By Table XVI., the chord of 18° on a 1° curve is 1,792.7 feet. That of a 4° curve is therefore 448.2 feet, half of which = 224.1, = A D. The mid. ord. of 18° on a 1° curve, by the same table, is 70.54 feet; one-fourth of which, or 17.635, is the mid. ord. B D, corresponding to the same angle on a 4° curve. In order to find what angle on the 6° curve this mid. ord. B D, = 17.635 feet, corresponds to, multiply it by 6, and seek the product, 105.81, in Table XVI., where it is found, nearly enough for field-practice, opposite the angle 22° 04′. The chord of that angle, on a 1° curve, is seen at the same time in the adjoining column to be 2,193.2 feet; on a 6° curve it is therefore 365.5 feet, one-half of which, = 182.75 feet, = D C, and one-half of 22° 04′ = 11° 02′, = the angle covered by the arc B C. Thus are found the angle at A = 9°, the angle at C = 11° 02′, and the distance A C = 224.1 + 182.75, = 406.85 feet. The angle 11° 02′ corresponds to a length of 1.84 feet on the 6° curve; C, therefore, falls at stake 36.25 + 1.84 = 38.09. With these data the field-work is obvious.

2. Second Method. — Having reached the point A, and determined the arc A B = 9°, as above, find in Table XVI. the ap. dist. 450.95 feet, corresponding to the given arc, one-fourth

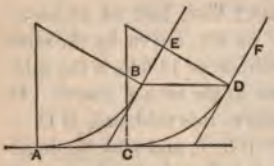
of which = 112.7 feet, = ap. dist. for the 4° curve. Move to E, deflect 9° R; range out the line E F, made up of E B = A E = 112.7 feet, and B F any convenient distance, say 90 feet. This 90 feet is the assumed ap. dist. of some unknown angle on the 6° curve. To find the angle, multiply 90 by 6, and seek the product, 540, in the **A D** column of Table XVI., where it is found opposite 10° 46′. By moving then to F, deflecting 10° 46′ R, and measuring F C = 90 feet, the point C is fixed on the second curve.

3. Should unexpected obstacles be met in carrying out either of these plans, the triangles A G C or E G F may be solved, and the point C fixed by means of the lines A G, G C.

4. The application of the foregoing methods to turning obstacles on simple curves needs no special instance.

XXVIII.

TO SHIFT A P. C. SO THAT THE CURVE SHALL TERMINATE IN A GIVEN TANGENT.



1. Suppose a 3° curve A B to have been located, containing an angle of 44° 26′, and ending in tangent B E: required, that it shall end in tangent D F, parallel to B E. It is plain, from the diagram, that if the curve and its initial tangent be moved forward, like the blade of a skate, until the terminal tangent merges in D F, the P. T. will have traversed the line B D, equal and parallel to A C. If, therefore, on the ground at B, the angle E B D, equal to the whole angle consumed by the curve, in this case 44° 26′, be laid off to the right, and the distance B D to the range of the proposed terminal tangent be measured, the equal distance A C, from the original to the required P. C., is thus directly ascertained.

Should such direct measurement be impracticable, range out the tangent B E, and, at any convenient point, measure the distance from it square across to the proposed terminal tangent D F, say 56 feet. Then in the right triangle B E D, *making BD radius,* we have given the angle at B = 44° 26′, and the sine E D = 56 feet. Hence, by trigonometry, E D ÷ *nat. sin.* 44° 26′, or 56 ÷ 0.7, = B D = 80 feet, = distance A C along the initial tangent, from the erroneous to the correct P. C.

2. This problem occurs more frequently than any other in the field; and the young engineer should have it by heart, that the distance square across between terminal tangents, divided by the natural sine of the total angle turned, will give him the distance he is to advance or recede with his P. C. to make a fit.

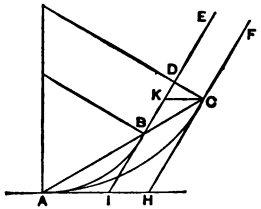
3. Excepting on precarious rocky steeps, city streets, or like exact confines, to strike within two feet of any point designated in the project, may be considered striking the mark. Astronomical nicety, whether with transit or level, in an ordinary railroad location, is mere waste of time.

4. The observant reader will not fail to perceive that the foregoing rule applies to systems of curves, or to compound lines also, the angle E B D being the angle included between the initial and terminal tangents, let what flexures or indirections soever have been interposed; and that, if the angle referred to be either 180° or 360°, adjustment by shift of P. C. is impracticable. In those cases, a change of radius becomes necessary.

XXIX.

TO SUBSTITUTE FOR A CURVE ALREADY LOCATED, ONE OF DIFFERENT RADIUS, BEGINNING AT THE SAME POINT, CONTAINING THE SAME ANGLE, AND ENDING IN A FIXED TERMINAL TANGENT.

1. Suppose the 4° curve A B, containing an angle of 32° 20′, to have been located, and that it is required to substitute for it another curve A C, which shall end in a parallel tangent C F, 60 feet to the right.



First Method.—Find the length of the long chord A C, = A B + B C. Referring to Table XVI., the chord of a 1° curve for 32° 20′ is seen to be 3,190.8 feet; that of a 4° curve, therefore, = 797.7 feet, say 798 feet, = A B. To find B C, solve the triangle B D C, observing that the angle D B C = B A I = one-half of the central angle 32° 20′, = 16° 10′, and that D C = 60 feet. Then D C ÷ *nat. sin.* 16° 10′ = 60 ÷ .278 = say 216 feet, = B C. Hence A C = A B + B C = 798 + 216 = 1,014 feet.

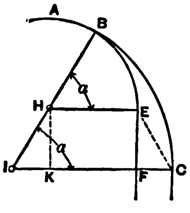
Having thus found the length of chord A C, the radius and rate of curvature may be deduced as in X.

Or, dividing the tabular chord of 32° 20′ by chord A C = 1,014, the degree of the required curve is ascertained directly to be 3.15, equivalent to 3° 09′.

2. SECOND METHOD. — Find the apex distance A H, = A I + I H. The tabular ap. dist. of 32° 20′ divided by 4 gives A I = 415 feet. In the triangle K D C, the side D C ÷ *nat. sin.* K = 60 ÷ *nat. sin.* 32° 20′, = 112 feet = K C = I H. Then A H = A I + I H = 415 + 112 = 527 feet; and the tabular ap. dist. 1,661 ÷ 527 gives 3.15, equivalent to 3° 09′, the degree of the required curve A C, as before.

XXX.

HAVING LOCATED A CURVE *A B C*, TO FIND THE POINT B AT WHICH TO COMPOUND INTO ANOTHER CURVE OF GIVEN RADIUS, WHICH SHALL END IN TANGENT *E F*, PARALLEL TO THE TERMINAL TANGENT OF THE ORIGINAL CURVE, AND A GIVEN DISTANCE FROM IT.



1. To find B, the angle B I C must be found. Call the given distance between tangents D; the larger radius, R; the smaller one, *r*; the required angle, *a*. Then, referring to the figure, observe that in the triangle I H K, I H being radius, I K is the *cosine a;* i.e., I K ÷ I H = *nat. cosine a.* But I H = R — *r*; I K = I C — K C, and K C = K F or H E + F C, = *r* + D; i.e., I K = R — *r* — D. Hence *nat. cosine* $a = (R - r - D) \div (R - r) = 1 - D \div (R - r)$.

The same reasoning would apply if A B E were the curve first located, and a terminal curve of larger radius required to be put in.

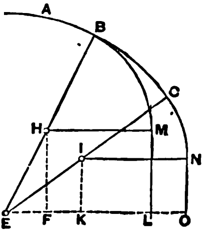
2. We have, then, the following general rule for such cases: Divide the perpendicular distance between terminal tangents by the difference of the radii, and subtract the quotient from unity; the remainder is the natural cosine of the angle of retreat along the located curve to the required P. C. C.

Example.

3. A 3° curve on the ground, to find the P. C. C. of a 5° curve striking 27 feet to the right. Here $D = 27$; $R - r = 1{,}910 - 1{,}146, = 764$; $D \div (R - r) = 27 \div 764, = .03534$; and $1 - .03534 = .96466 =$ *nat. cosine* 15° 17′. We must go back, therefore, 509 feet on the 3° curve, to compound into the 5° curve. Had the 5° curve been located first, we must have gone back 306 feet to begin the 3° curve which should strike 27 feet to the left. In either case, time might be saved by moving directly from E to C, or the reverse, and spotting in the curve backwards. To do this, we have in the right triangle F E C, the angle $E =$ half of 15° 17′, $=$ 7° 38½′, and the side $F C = 27$ feet. Then $E C = 27 \div$ *nat. sin.* 7° 38½′, $= 203$ feet; and if E were stake 54.20 on the 5° curve, B would fall at stake $54.20 - 3.06, = 51.14$; and C, the P. T. of the 3° curve, at $51.14 + 5.09, =$ stake 56.23.

XXXI.

TO SHIFT A P. C. C., SO THAT THE TERMINAL BRANCH OF THE CURVE SHALL END IN A GIVEN TANGENT.



First Case: the terminal branch having the shorter radius.

1. Suppose the compound curve A C N located, and that it is required to fix a new P. C. C. at B, from which the terminal branch B M shall merge in tangent M L, a given distance from N O. To fix B, the central angle B H M of the new terminal branch must be found, and substituted for *C I N. Call the* longer radius R; the shorter one, r; the dis-

tance asunder of the terminal tangents, D; the central angle, C I N, = I E K, of the located terminal branch, b; and the central angle, B H M, = H E F, to be substituted for it, a.

In the right triangle, E I K, $EK = EI \cos. IEK = (R - r) \cos. b$.

In the right triangle H F E, $EF = EH \cos. HEF = (R - r) \cos. a$.

Also, $FK = LO = D$, since each is equal to $r - KL$.

Then $EF = EK - FK$; i.e., $(R - r) \cos. a = (R - r) \cos. b - D$.

Hence *nat. cosine* $a =$ *nat. cosine* $b - [D \div (R - r)]$.

Were the curve B M located, and the curve C N to be substituted for it, — that is to say, were a given and b required, — we should have, by transposition, *nat. cos.* $b =$ *nat. cos.* $a + D \div (R - r)$.

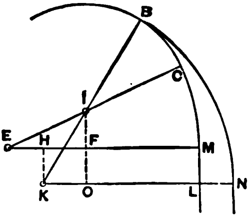
Example.

A 3°, compounding into a 5° curve at C, which consumes an angle C I N, = 30° 22′, and ends in a tangent, N O, which is found, by measurement of L O, to be 34 feet too far to the left.

Here, D = 34, R = 1,910, r = 1,146, b = 30° 22′; and, by the solution, *nat. cos.* a = *nat. cos.* 30° 22′ − 34 ÷ [1,910 − 1,146] = 0.8628 − (34 ÷ 764).

34	log. 1.531479
764	log. 2.883093
.0445	log. $\bar{2}.648386$

Then 0.8628 − 0.0445 = 0.8183 = *cos.* 35° 05′, = angle a; $a - b$ = B H M − C I N = B E C = the angle of retreat from the erroneous P. C. C. = 35° 05′ − 30° 22′ = 4° 43′, equivalent to 157 feet, on the 3° curve, from C to B.



2. SECOND CASE: the terminal branch having the longer radius.

Let B N represent the terminal branch located with central angle I K O = b, and suppose it required to determine the new arc C M, with central angle I E F = a. Call the longer radius R, the shorter one r; the distance L N between tangents, D. In the right triangle IKO, $KO = KI$, *cos.* $IKO = (R - r)$ *cos.* b. In the right triangle FIE, $EF = EI$, *cos.* $IEF = (R - r)$ *cos.* a. Also, $EH = LN = D$, since each is equal to $R - KL$.

Then $EF = EH + HF = EH + KO$; i.e., $(R - r)$ *cos.* $a = (R - r)$ *cos.* $b + D$. Hence *nat. cos.* $a =$ *nat. cos.* $b + D \div (R - r)$.

Were the curve CM located, and the curve BN to be substituted for it, that is to say, were a given and b required, we should have, by transposition, *nat. cos.* $b =$ *nat. cos.* $a - D \div (R - r)$.

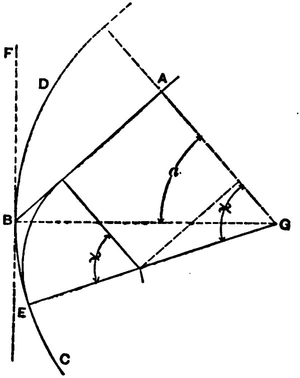
Example.

A 5° compounding into a 3° curve at B, which consumes an angle of 44° 20′, and terminates at N, 28 feet too far to the left. Here $D = 28$, $R = 1{,}910$, $r = 1{,}146$, $b = 44° 20′$; and, by the solution, *nat. cos.* $a =$ *nat. cos.* $44° 20′ + 28 \div 764$. The *nat. cos.* $44° 20′ = 0.69883$; $28 \div 764 =$ *log.* $1.447158 -$ *log.* $2.883093 =$ *log.* $\bar{2}.564065$, corresponding to the decimal 0.03665, which, being added to *nat. cos.* 44° 20′, gives 0.73548, the *nat. cos.* 42° 29′. Then $BKN - CEM = 44° 20′ - 42° 29′ = 1° 51′ =$ angle BIC, equivalent on a 5° curve to 37 feet, which therefore is the distance around the arc from B, the erroneous P.C.C., to C, the correct one.

3. From these formulas the following general rule may be drawn: Divide the distance between terminal tangents by the difference of the radii, and call the quotient Q. Find the natural cosine of the terminal arc already located, and call it C. The sum or the difference of Q and C will be the natural cosine of the terminal arc to be substituted for that already located. With radii in the order R, r, should the terminal tangent located strike $\left\{\begin{matrix}\text{inside}\\ \text{outside}\end{matrix}\right\}$ the proposed tangent; or, with radii in the order r, R, should the terminal tangent located strike $\left\{\begin{matrix}\text{outside}\\ \text{inside}\end{matrix}\right\}$ the proposed tangent, — take the $\left\{\begin{matrix}\text{sum}\\ \text{difference}\end{matrix}\right\}$ of Q and C for the required cosine.

XXXII.

HAVING LOCATED A TANGENT, *A B*, INTERSECTING A CURVE, *C D*, FROM THE CONCAVE SIDE, TO FIND THE POINT *E* ON SAID CURVE AT WHICH TO BEGIN A CURVE OF GIVEN RADIUS WHICH SHALL MERGE IN THE LOCATED TANGENT.



1. Place the transit at the intersection point B. Set points at equal distances therefrom in both directions on the curve already located, by means of which the direction of a tangent to that curve at B may be fixed, and the angle F B A measured. Call that angle a; and, as shown in the figure, suppose the located curve to be prolonged into a terminal tangent, parallel with the newly located tangent A B. Complete the diagram. Call the larger radius R; the proposed radius, r; the central angle of the proposed curve, x. Then, obviously, the line $AG = R \cos. a$. It is also equal to $(R - r) \cos. x + r$. That is to say, $R \cos. a = (R - r) \cos. x + r$. Hence $\cos. x = (R \cos. a - r) \div (R - r)$; and $x - a =$ angle B G E, subtended by the arc B E, from which the length of the arc may be deduced, and the point E ascertained.

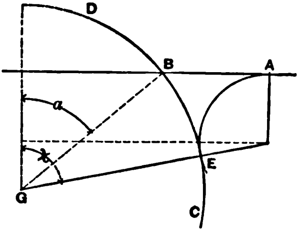
Example.

D C, a 1° curve; angle $a = 64° 32'$: to connect with a 4° curve. Here $\cos. x = (5{,}730 \times 0.43 - 1{,}433) \div (5{,}730 - 1{,}433) = 0.24 = \cos. 76° 06'$; and $x - a = 11° 34'$, equivalent to a distance from B around the 1° curve of 1,157 feet to E, the point at which to begin the 4° curve.

XXXIII.

HAVING LOCATED A TANGENT, *A B*, INTERSECTING A CURVE, *C D*, FROM THE CONVEX SIDE, TO FIND THE POINT *E* ON SAID CURVE AT WHICH TO BEGIN A CURVE OF GIVEN RADIUS WHICH SHALL MERGE IN THE LOCATED TANGENT.

1. This problem is analogous to the preceding one. The preparatory steps are the same in both. Having found the angle a, however, it will be manifest to the attentive reader, that, in this case, $R \cos. a = (R + r) \cos. x + r$. Hence $\cos. x = (R \cos. a - r) \div (R + r)$.

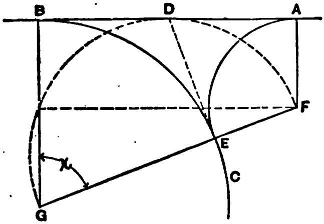


Example.

2. D C, a 1° curve; angle $a = 64° 32'$: to connect with a 4° curve. Here $\cos. x = (5{,}730 \times 0.43 - 1{,}433) \div (5{,}730 + 1{,}433) = 0.1439 = \cos. 81° 43'$; and $x - a = 17° 11'$, equivalent to a distance from B around the 1° curve of 1,718 feet to E, the point at which to start the 4° curve.

XXXIV.

TO LOCATE A *Y*.



1. The processes of the two former problems may be adopted. In this case the angle a vanishes, and the $\cos. x$ clearly is equal to $(R - r) \div (R + r)$.

2. Another solution of the Y problem is as follows:—

Draw the tangent E D intersecting the tangent B A. Then is $BD = DA$, for the reason that each is equal to D E. Make G F $= R + r$, the diameter of a semicircle. Said semicircle touches tangent B A at D, its middle point; and D E being perpendicular to G F, we have by geometry G E : D E :: D E : E F; i.e., G E × E F, or $R \times r$, $=$ D E^2. Hence D E $=$ B D $=$ D A $= \sqrt{R \times r} = R$ *tan.* $\frac{1}{2} x$, and we are thus enabled to fix the points E and A.

3. In the two foregoing problems, the angle consumed by curve E A is $= 180° - x$.

Example.

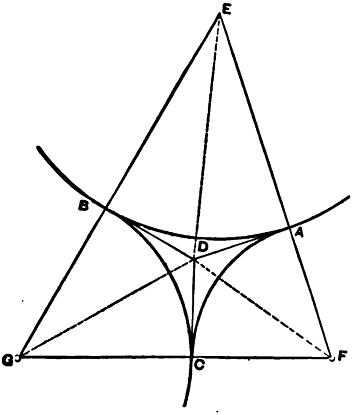
B E, a 2½° curve located; B A, a tangent: to complete the Y with a 6° curve, E A.

By the first method, *cos.* $x = (R - r) \div (R + r) = (2{,}292 - 955) \div (2{,}292 + 955) = 1{,}337 \div 3{,}247 =$ *log.* 3.126131 − *log.* 3.511482 $= \bar{1}.614649$, which corresponds to *log. cos.* 9.614649, or to the decimal number 0.4118, indicating in either case the angle 65° 41′ $= x$.

D E $=$ B D $=$ D A $= R$ *tan.* $\frac{1}{2} x = 2{,}292 \times 0.6455 = 1{,}479.4$. D E may be found also by reference to Table XVI., where the ap. dist. of a 1° curve for 65° 41′ is seen to be 3,698.6. Dividing this number by 2½, we have 1,479.4, as above.

Or, by the second method, —

$$DE = \sqrt{R \times r} = \sqrt{2188860} = 1{,}479.4.$$



Having thus the means of fixing points E, D, and A, the curve E A can be laid down.

4. *If* B A *is curved convex to the* Y, construct the figure as in margin, and reason thus: —

In the triangle E G F, formed by lines connecting the curve-centres, the sides are respectively equal to the sums of the contiguous radii: the angles may therefore be found as in Case III., Trigonometry.

Lines drawn bisecting the central angles of the several curves will pass through the points of intersection of the tangents to those curves severally. But lines so drawn in this case bisect also the angles of a triangle, and, demonstrably by geometry, meet in one point equidistant from the three sides of the triangle. That point, therefore, must be a common P. I. for all the curves, and that equidistance the "ap. dist." length common to them all.

Example.

Given B A, a 3°, and B C, a 4° curve: to complete the Y with a 5° curve, C A.

E F = 1,910 + 1,146 = 3,056.
G F = 1,433 + 1,146 = 2,579.
E G = 1,910 + 1,433 = 3,343.

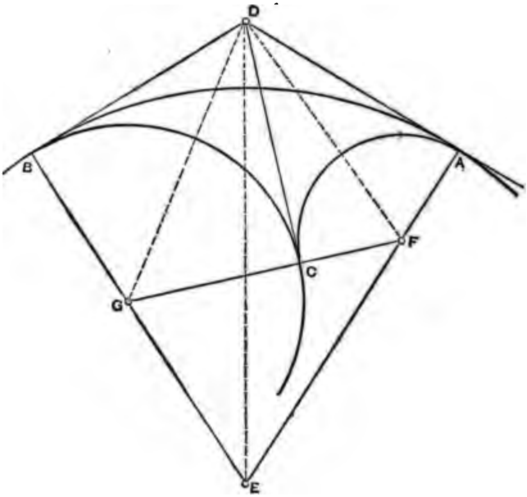
Then, by Case III., Trigonometry, —

As E G,	3,343	log. (a. c.)	6.475864
Is to E F + G F,	5,635	log. . .	3.750894
So is E F — G F,	477	log. . .	2.678518
To diff. of segments of E G,	804		2.905276

Adding half the difference to half the sum of the segments of the base E G, we shall have the greater of them; i.e., (3,343 + 804) ÷ 2 = 2,073.5, which is the *cos.* E, E F being radius. Hence 2,073.5 ÷ 3,056 = *log.* 3.316704 — *log.* 3.485153 = 9.831551 = *cos.* 47° 16′ = E. By Table XVI., the ap. dist. of a 1° curve corresponding to this angle is 2,507.3: that of a 3° curve, therefore, is 835.8 = the common ap. dist. B D or D A. Multiplying the common ap. dist. by 4, we shall find opposite the product in Table XVI. the central angle of the 4° curve to be 60° 32′; multiplying it by 5, we find, in like manner, the central angle of the 5° curve to be 72° 12′. Arc B A, = 47° 16′, is equivalent to 1,575 feet on the 3° curve; arc B C, = 60° 32′, is equivalent to 1,513 feet on the 4° curve. Points being thus fixed at A and C, curve C A can be laid on the ground.

5. *If curve* B A *is concave to the* Y, the radii being given, construct the figure as follows: —

First draw the triangle G F E, the sides of which are obviously derived from the given radii. Prolong the sides E G and E F indefinitely. Bisect the exterior angles at G and F with lines meeting at D, and from D let fall perpendiculars on E B, E A, and G F. Then, comparing triangles G B D, G C D, the angles at G are equal by construction; the angles at B and C are right angles, the side G D common. Hence the triangles are equal in all their parts: B G = G C, and B D = D C. By like reasoning, it appears that C F = F A, and D A = D C. The point D being equidistant from the right lines E B, E A, which limit angle E, a line bisecting that angle will strike point D.



6. It may be remarked, therefore, that lines bisecting the vertical angle and the exterior angles contained between the base and the prolongation of the sides of any triangle, will meet in a point equidistant from the base and the said prolongations. We thus have in the figure all the conditions for fitness of the curves. It remains only to solve the triangle G F E, seeing that from its angles the required central angles can be obtained.

Example.

B A, a 1°, B C, a 6° curve, located: to complete the Y with *an 8° curve, C A.*

In triangle G F E, —

$$E\,F = 5{,}730 - 717 = 5{,}013.$$
$$E\,G = 5{,}730 - 955 = 4{,}775.$$
$$G\,F = 955 + 717 = 1{,}672.$$

Then, by Case III., Trigonometry, —

As E F . . .	5,013	log. (a. c.)	6.299902
Is to E G + G F,	6,447	log. . .	3.809358
So is E G — G F,	3,103	log. . .	3.491782
To diff. seg. of base,	3,991 . . .	log. . .	3.601042

The longer segment, therefore, is 4,502; the shorter, 511. *Cos.* E = the longer segment divided by E G = 4,502 ÷ 4,775 = *log.* 3.653405 — 3.678973 = 9.974432 = *cos.* 19° 28′ = angle E.

Cos. G F E = the shorter segment divided by G F = 511 ÷ 1,672 = *log.* 2.708421 — *log.* 3.223236 = 9.485185 = *cos.* 72° 12′ = angle G F E.

The central angle, B G C, of the 6° curve, is equal to 180 — F G E = the sum of the angles at E and F = 72° 12′ + 19° 28′ = 91° 40′, making the arc B C = 1,528 feet. The arc B A, equivalent to 19° 28′ of a 1° curve, = 1,947 feet. Points C and A being thus ascertained, curve A C may be located. It will consume an angle = 180° — 72° 12′ = 107° 48′, equivalent, on an 8° curve, to 1,347.5 feet.

XXXV.

TO LOCATE A TANGENT TO A CURVE FROM AN OUTSIDE FIXED POINT.

1. If the ground is open, and the curve can be seen from the fixed point, it may be marked by stakes or poles at short intervals, and the tangent laid off without more ado.

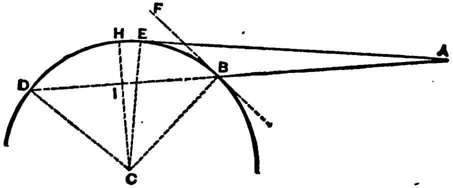
2. Suppose, however, that on cumbered ground a trial tangent, A B, has been run out, intersecting the curve at B: it is required then to find the angle B A E, in order that the true tangent A E may be laid down.

Example.

A B = 1,500 feet; D H B, a 4° curve; angle F B D = 20° 13′.

First, the angle F B D, between a tangent and a chord, is equal to half the central angle subtended by the same chord. Angle D C B, therefore, = 40° 26′. By Table XVI., the chord of 40° 26′, for a 1° curve, = 3,960.2 feet; for a 4° curve, it is, say, 990 feet = D B; and D I = I B = 495 feet. The mid. ord. H I is, in like manner, found to be 88.25 feet. Deducting this from the radius of the 4° curve, we have I C = 1,344.4 feet.

Then I C ÷ I A = *tan.* I A C; i.e., 1,344.4 ÷ (495 + 1,500) = 0.674 = *tan.* 33° 59′ = angle I A C.



Next, by geometry, the proposed tangent A E = $\sqrt{AD \times AB}$ = $\sqrt{2{,}490 \times 1{,}500}$ = 1,932.6; and E C ÷ A E = *tan.* E A C = 1,432.69 ÷ 1,932.6 = 0.7413 = *tan.* 36° 33′ = angle E A C. Then E A C − I A C = 36° 33′ − 33° 59′ = 2° 34′ = angle B A E, the angle required, which can accordingly be laid off from the fixed point A, and the tangent located.

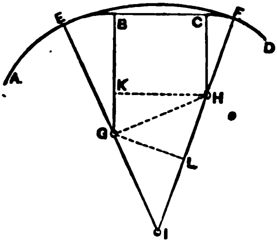
XXXVI.

TO SUBSTITUTE A CURVE OF GIVEN RADIUS FOR A TANGENT CONNECTING TWO CURVES.

Example.

1. A B, a 4° curve; B C = 774 feet; C D, a 6° curve: to put in the 1° curve, E F.

Sketch the figure as in margin, H K being parallel and equal to B C. Then K G = B G − B K or C H = 1,433 − 955 = *478 feet;* *K H* ÷ G K = 774 ÷ 478 = 1.62 = *tan.* 58° 19′ = *angle K G H;* and K H ÷ *sin.* 58° 19′ = 774 ÷ 0.851 = 909.6 *feet = G H.*



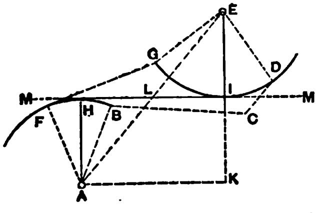
In the triangle G H I we have then the sides given; namely G H = say, 910 feet, H I = 5,730 — 955 = 4,775 feet, and G I = 5,730 — 1,433 = 4,297 feet: to find the angles.

Under Case 3, Trigonometry (III.), $IH : IG + GH :: IG - GH : IL - LH$; i.e., 4,775 : 5,207 :: 3,387 : 3,693, the difference of the segments into which the base I H is divided by a perpendicular from G. Adding half the difference of the segments thus found to half their sum, the longer segment, I L, is found to be 4,234 feet; subtracting half the difference from half the sum, the shorter segment, L H, is found to be 541 feet.

Then H L ÷ H G = 541 ÷ 910 = 0.5945 = *cos.* 53° 31′ = angle G H I. In like manner, dividing I L by I G, we find the angle G I H to be 9° 49′. The sum of these angles = angle E G H = 63° 20′, for the reason that each is equal to 180 — H G I. Finally, E G H — K G H = 63° 20′ — 58° 19′ = 5° 01′ = angle E G B, equivalent to a distance from B of 125 feet around the 4° curve to the P. C. C. at E; and G I H — E G B = 9° 49′ — 5° 01′ = 4° 48′ = angle C H F, equivalent to a distance from C of 80 feet around the 6° curve to the P. C. C. at F.

XXXVII.

TO RUN A TANGENT TO TWO CURVES ALREADY LOCATED.



1. If one curve be visible from the other, or if both be visible from some intermediate point, mark them on the ground with stakes at short intervals. The points M or L in the range of the required tangent may then be fixed by one or two trial settings of the transit, and *the line put in.*

2. Should obstacles prohibit this plan, measure any convenient line, FG or BCD, from one to the other curve, and, completing the traverse AFGE or ABCDE, determine thence the bearings and distances asunder of the centres A and E. The right triangle AEK, in which EK = the sum of the radii, may then be solved, and the points H and I ascertained as in the following example:—

Example.

F B, a 4° curve; G D, a 6° curve.	N.	S.	E.	W.
A B, N. 20° E., 1,433 feet . .	1,346.6		490.0	-
B C, East, 3,570 feet . .	-		3,570.0	-
C D, N. 34° E., 1,800 feet . .	1,492.2		1,006.2	-
D E, N. 45° W., 955 feet . .	675.2		-	675.2
	3,514.0		5,066.2	675.2

Total northing, 3,514 feet; total easting, 4,391 feet.

Then 4,391 ÷ 3,514 = 1.2496 = *tan.* 51° 20′ = bearing AE; and 4,391 ÷ *sin.* 51° 20′ = 5,573 feet = distance AE. Also, EK ÷ AE = (1,433 + 955) ÷ 5,573 = *sin.* 25° 22′ = angle EAK; and angle AEK = 90° 00′ — 25° 22′ = 64° 38′. Hence the bearing of AK or HI is N. 76° 42′ E., and that of AH or IE, N. 13° 18′ W.

Since AB bears N. 20° E., the angle HAB = 20° 00′ + 13° 18′ = 33° 18′, equivalent to a distance of 833 feet from B around the 4° curve to the required P. T. at H; and, since DE bears N. 45° 00′ W., the angle IED = 45° 00′ — 13° 18′ = 31° 42′, equivalent to a distance of 528 feet from D around the 6° curve to the required P. C. at I.

3. Should the curves turn in the same direction, the side EK of the triangle AEK is equal to the difference of the radii instead of their sum. In other respects, the method exemplified will apply to that case also.

4. The preceding solution may be useful as an exercise. But the problem is one of rare occurrence, and the conditions must be extraordinary which prevent a close approximation, at least, to the true line in the field. The better way in actual practice, then, is to run out a trial tangent as nearly right as possible. If it errs by passing outside the objective curve, close with a compound (XXIX.); if that error be inadmissible, or if it errs by cutting the objective curve, measure the miss, and divide it by the length of the trial tangent. The quotient

will be the natural tangent of the angle of retreat or advance on the first curve required to make the tangent fit.

5. A still closer adjustment would be, after determining the angle approximately as above, to find the "tangents" corresponding to it for the two curves in Table XVI. Subtract the sum of these tangents from the length of the trial line, if it cuts the objective curve; add the sum, if it passes outside. With the number thus found, divide the measured amount of error for the tangent of the angle of retreat or advance, as the case may be.

6. Suppose, for illustration, that a trial tangent, bearing by needle N. 54° 30′ E., is run out from stake 24.80 of a 4° curve, intending to touch a 6°, but is found to cut it. Suppose further that the objective 6° curve was laid down and numbered in the direction of approach towards the 4° curve; that its P. C. is stake 25.10, and the magnetic bearing of its initial tangent S. 30° 30′ W. The angle, then, between the bearing of the trial tangent and that of the initial tangent of the 6° curve, is 24°, corresponding to a distance of 400 feet on the latter curve. At stake 25.10 + 4.0 = 29.10, therefore, a tangent to the 6° curve would be parallel to the trial tangent. Go forward on the trial tangent, accordingly, to a point opposite 29.10, and measure the distance square across to that plus on the 6° curve. Assuming the trial tangent to be 2,500 feet long, and the amount of the miss to be 87 feet, the *nat. tan.* of the angle of error is 0.0348 = *tan.* 2°. By the method in (4), this calls for a shift of the P. T. 50 feet ahead on the 4° curve, making the new P. T. 24.80 + 0.50 = stake 25.30, and advances the P. T. of the 6° curve to stake 29.43 of that numeration.

The method in (5), applied to this case, brings the angle of error 2° 02′, instead of 2°, equivalent to a deviation of 1¼ feet scant in half a mile from the line corrected by the method in (4), and agreeing exactly with the correction determined by the method in (2).

TRACK PROBLEMS.

XXXVIII.—LI.

TRACK PROBLEMS.

XXXVIII.

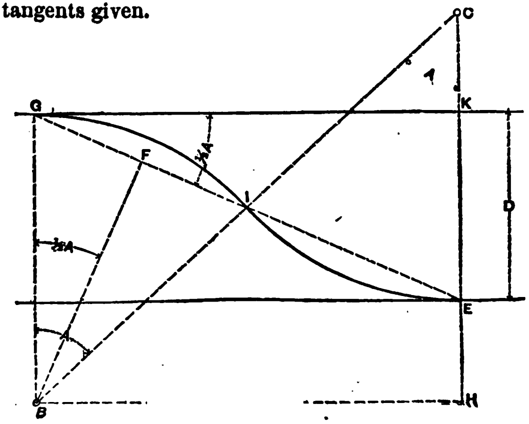
REVERSED CURVES.

The following problems will be useful in laying off turnouts, the adjustment of tracks near stations or shops, and the like; but reversed curves should never be used on the main line between stations, where they are both objectionable and unnecessary. Ground which allows any permissible location at all will allow straight reaches of at least two hundred or three hundred feet between curves of contrary flexure; and in every case it is worth the small additional outlay to make such a location.

XXXIX.

TO CONNECT TWO PARALLEL TANGENTS BY A REVERSED CURVE HAVING EQUAL RADII.

1. The radius R, and the perpendicular distance D, between the tangents given.



Draw the tangents, radii, and curves, fixing the P. R. C. midway of D.

Draw the chords G I, I E, the line B F perpendicular to G I, and the line E H in prolongation of radius C E to an intersection with B H passed through centre B parallel to tangents.

That I falls midway of D, follows from the necessary symmetry of the figure; and G I E must be a straight line, because the radii B I, I C, perpendicular to a common tangent at the same point, form a straight line, to which the chords G I, I E, are equally inclined.

$$CH \div CB = \textit{cos.}\ A;\ \text{but}\ CH = 2R - D,\ \text{and}\ CB = 2R.$$
$$\therefore \textit{cos.}\ A = (2R - D) \div 2R.$$
$$BH = BC\ \textit{sin.}\ A = 2R\ \textit{sin.}\ A;$$
$$GF = R\ \textit{sin.}\ \tfrac{1}{4} A;\ GE = 4\,GF.$$
$$\therefore GE = 4R\ \textit{sin.}\ \tfrac{1}{4} A,\ \text{and}\ GI\ \text{or}\ IE = 2R\ \textit{sin.}\ \tfrac{1}{4} A.$$

Observe, that, in the right triangles G K E and B G F, the angles at G and B are each equal to ¼ A: hence the triangles are similar.

Example.

R = 800 feet, D = 24 feet.

To find angle A.

$$\textit{Cos.}\ A = (2R - D) \div 2R = 1{,}576 \div 1{,}600 = 0.985 = \textit{nat. cos.}\ 9^\circ\ 56'.$$

B H may then be found = 2 R *sin.* A = 1,600 × 0.1725 = 276 feet, and laid off from the P. C. at G to K, the point E being fixed by a right angle from K.

Or G E may be found = 4 R *sin.* ¼ A = 3,200 × 0.866 = 277.1 feet, and laid off from G to E, the point I being fixed 138.5 feet from G, and angle K G E made equal to half of A = 4° 58′.

2. The distances G K and D given, to find R.

In triangle G K E, K E = D.

$$D \div GK = \textit{tan.}\ \tfrac{1}{4} A;\ D \div \textit{sin.}\ \tfrac{1}{4} A = GE;\ \text{and}\ GE \div \textit{sin.}\ \tfrac{1}{4} A = 4R.$$

Or, having found G E, we have from the congruity of triangles G K E, B F G,

$$D : GE :: \tfrac{1}{4} GE\ \text{or}\ GF : R.$$
$$\therefore R = GE^2 \div 4D.$$

Example.

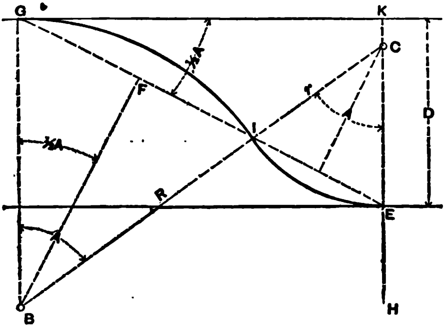
G K = 300 feet, D = 28 feet.

D ÷ G K	Log.	28	1.447158
	Log.	300	2.477121
= *Tan.* ½ A		5° 20′	8.970037
D ÷ *sin.* ½ A	Log.	28	1.447158
	Sin.	5° 20′	8.968249
= G E		301.24	2.478909
G E ÷ *sin.* ½ A	*Sin.*	5° 20′	8.968249
= 4 R.		3,241	3.510660

∴ R = 810.2.

XL.

TO CONNECT TWO PARALLEL TANGENTS BY A REVERSED CURVE HAVING UNEQUAL RADII.



1. Given the perpendicular distance, D, between two parallel tangents, and the unequal radii, R and *r*, of a reversed curve, to find the central angles, A, the chords, and the straight reach, G K, of the curve.

Cos. $\mathrm{A} = \mathrm{CH} \div \mathrm{BC}$; but $\mathrm{CH} = (\mathrm{R} + r) - \mathrm{D}$, and

$$\mathrm{BC} = \mathrm{R} + r.$$

$$\therefore \textit{Cos. } \mathrm{A} = (\mathrm{R} + r - \mathrm{D}) \div (\mathrm{R} + r).$$

The straight reach $\mathrm{GK} = \mathrm{BH} = (\mathrm{R} + r)$ *sin.* A.
The sum of the chords $\mathrm{GE} = \mathrm{GK} \div$ *cos.* ½ A.

$$\mathrm{GI} = 2\,\mathrm{R}\ \textit{sin. } \tfrac{1}{2}\,\mathrm{A}.$$

$$\mathrm{IE} = 2\,r\ \textit{sin. } \tfrac{1}{2}\,\mathrm{A} = \mathrm{GE} - \mathrm{GI}.$$

Example.

$\mathrm{D} = 28$, $\mathrm{R} = 955$, $r = 574$.

Cos. $\mathrm{A} = (\mathrm{R} + r - \mathrm{D}) \div (\mathrm{R} + r) = 1{,}501 \div 1{,}529.$

1,501 . . . log. 3.176381
1,529 . . . log. 3.184407
Cos. A, 10° 59′ 9.991974

$\mathrm{GK} = (\mathrm{R} + r)$ *sin.* A.

$\mathrm{R} + r$, 1,529 . . . log. 3.184407
Sin. A, 10° 59′ . . . log. 9.279948
$\mathrm{GK} = 291.3$ 2.464355

$\mathrm{GE} = \mathrm{GK} \div$ *cos.* ½ A.

GK, 291.3 . . . log. 2.464355
Cos. ½ A, 5° 29½′ . . . log. 9.998014
$\mathrm{GE} = 292.6$ 2.466341

$\mathrm{GI} = 2\,\mathrm{R}$ *sin.* ½ A.

2 R, 1,910 . . . log. 3.281033
Sin. ½ A, 5° 29½′ . . . log. 8.980916
$\mathrm{GI} = 182.8$ 2.261949

$$\mathrm{IE} = \mathrm{GE} - \mathrm{GI} = 292.6 - 182.8 = 109.8.$$

2. The distances GK and D, and one of the unequa *radii,* R, given, to find the other radius, *r,* and the centra *angles,* A.

Example.

$K = 422,\ D = 30,\ R = 2{,}292.$

$\mathit{Tan.}\ \frac{1}{2} A = D \div GK.$

$D = 30$ . . . log. 1.477121
$GK = 422$ . . . log. 2.625312
Tan. $\frac{1}{2}$ A, 4° 04′ 8.851809
$\therefore A = 8° 08′.$

$GE = D \div \mathit{sin.}\ \frac{1}{2} A.$

$D = 30$ . . . log. 1.477121
Sin. $\frac{1}{2}$ A, 4° 04′ . . . log. 8.850751
$\therefore GE = 423$ 2.626370

$GI = 2\,R\ \mathit{sin.}\ \frac{1}{2} A.$

$2\,R = 4{,}584$ . . . log. 3.661245
Sin. $\frac{1}{2}$ A, 4° 04′ . . . log. 8.850751
$GI = 325.1$ 2.511996
$GE - GI = 423 - 325 = 98 = IE.$

$r = \frac{1}{2}\,IE \div \mathit{sin.}\ \frac{1}{2} A.$

$\frac{1}{2}\,IE = 49$ . . . log. 1.690196
Sin. $\frac{1}{2}$ A, 4° 04′ . . . log. 8.850751
$r = 691$ 2.839445

XLI.

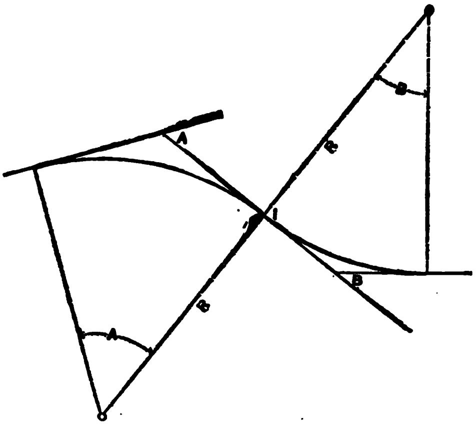
A REVERSED CURVE HAVING UNEQUAL A

Given the angles A and B, and the length A B of a line connecting two diverging tangents, to find the ra reversed curve to close the angles.

$AI = R \times \mathit{tan.}\ \frac{1}{2} A;\ BI = R \times \mathit{tan.}\ \frac{1}{2} B.$
$\therefore AB = R \times (\mathit{tan.}\ \frac{1}{2} A + \mathit{tan.}\ \frac{1}{2} B).$
$\therefore R = AB$ [illegible] $\mathit{tan.}\ \frac{1}{2} B).$

Example.

A = 16°, B = 10°, A B = 840.



A B, 840 . . . . log. 2.924279
½ A = 8°, *nat. tan.* 0.14054
½ B = 5°, *nat. tan.* 0.08749
Tan. ½ A + *tan.* ½ B = 0.22803 . . log. —1.357992
R = 3,600 . . . . 3.566287

This solution will apply also to the finding of the maximum radius for a simple curve which shall connect three tangents.

XLII.

A REVERSED CURVE BETWEEN FIXED POINTS.

Given the angles N and K, and the length of the straight line E F connecting two divergent tangents, to find the radius of a reversed curve from E to F, connecting the tangents.

1. Denote the angle E I C or D I F by I; the angle C E I, complement of N, by *n*; and the angle D F I, complement of K, by *k*.

Then, in triangle E C I, —

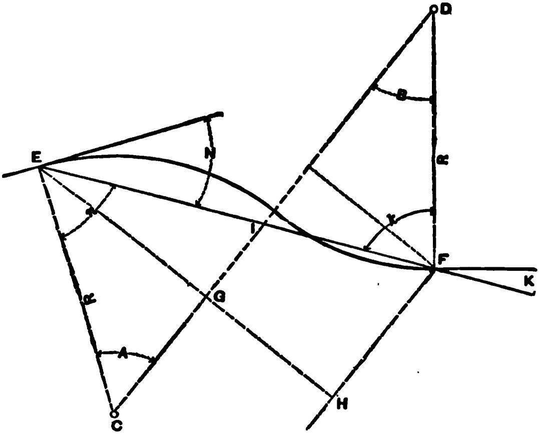
$$EC : CI :: \sin. I : \sin. n. \quad \therefore EC \times \sin. n = CI \times \sin. I$$

Also, in triangle D F I, —

$$DF : DI :: \sin. I : \sin. k. \quad \therefore DF \times \sin. k = DI \times \sin. I.$$

Adding these equations, we have —

$$EC \times \sin. n + DF \times \sin. k = (CI + DI) \times \sin. I.$$



But E C and D F are each equal to R; *sin.* n = *cos.* N; *sin.* k = *cos.* K; and C I + D I = 2 R.

Hence the equation becomes, —

$$R \times (\cos. N + \cos. K) = 2 R \times \sin. I.$$
$$\therefore \sin. I = (\cos. N + \cos. K) \div 2.$$

The foregoing elegant solution is abridged from Henck.

2. Angle A = 180 — (n + I); angle B = 180 — (k + I).

To find radius, draw F H parallel, and E H perpendicular, to C D.

Then E H = E F × *sin.* I.

But E H = E G + G H; E G = R × *sin.* A; and G H = R × *sin.* B.

$$\therefore EF \times \sin. I = R \times (\sin. A + \sin. B).$$
$$\therefore R = EF \times \sin. I \div (\sin. A + \sin. B).$$

Example.

$EF = 1{,}400,\ N = 30°,\ K = 20°.$

$Sin.\ I = (cos.\ N + cos.\ K) \div 2.$

N = 30°, *nat. cos.*	0.86603
K = 20°, *nat. cos.*	0.93969
	1.80572

$$1.80572 \div 2 = 0.90286 = nat.\ sin.\ 64° \ 32'.$$
$$\therefore I = 64° \ 32'.$$

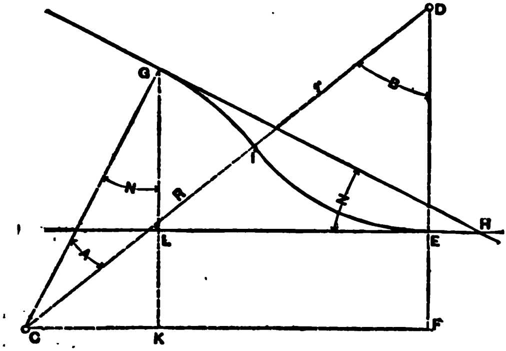
$A = 180° - (n + I) = 180° - (60° + 64° \ 32') = 55° \ 28'.$
$B = 180° - (k + I) = 180° - (70° + 64° \ 32') = 45° \ 28'.$
$R = EF \times sin.\ I \div (sin.\ A + sin.\ B).$

EF = 1,400		log. 3.146128
Nat. sin. I, 0.90286		log. —1.955621
EG = 1,264		3.101749
A = 55° 28′ *nat. sin.*	0.82380	
B = 45° 28′ *nat. sin.*	0.71284	
Sin. A + *sin.* B	1.53664	log. 0.186579
R = 822.6		2.915170

3. The young student should bear in mind that the addition or subtraction of the logarithms of two natural numbers gives a logarithm representing, not the sum or difference, but the product or quotient, of such numbers. When, therefore, as in the two foregoing cases, the sum or difference of two or more trigonometric functions — sines, tangents, and the like — is sought, the logarithm of the sum of the natural functions, and not the sum of their logarithms, is to be used. If, for example, *sin.* A × *sin.* B is required, the log. *sin.* A + log. *sin.* B = the logarithm of the product of the sines designated; but, if *sin.* A + *sin.* B is sought, the natural sines of those angles must be added together, and the logarithm of the sum of these natural functions must be used in making logarithmic calculations.

XLIII.

TO CONNECT TWO DIVERGENT TANGENTS BY A REVERSED CURVE.



1. ADVANCING TOWARDS THE INTERSECTION OF TANGENTS.

Given the angle of divergence, N, the initial P. C. at G, the distance G H, and the radii R, r, to find the central angles A and B.

$GK = CG \times \cos. N = R \cos. N.$
$GL = GH \times \sin. N.$
$GK - GL = LK$ or EF, CF being drawn parallel to LE.
$\cos. B = DF \div DC = (r + EF) \div (R + r).$
Angle $GCK = 90° - N$; angle $DCF = 90° - B.$
Angle $A = GCK - DCF = (90° - N) - (90° - B) = B - N.$

Example.

$N = 24° 30'$, $GH = 854$, $R = 1{,}440$, $r = 1{,}146.$

$GK = R \cos. N.$

R = 1,440 . . . log. 3.158362
Cos. N, 24° 30′ . . . log. 9.959023
G K = 1,310 . . . . . 3.117385

$GL = GH \times \sin. N.$

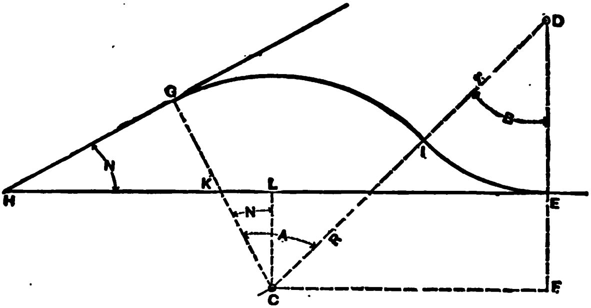
$GH = 854$ . . . log. 2.931458
Sin. N, 24° 30′ . . . log. 9.617727
$GL = 354$ 2.549185

LK or $EF = GK - GL = 1{,}310 - 354 = 956.$

$\cos. B = (r + EF) \div (R + r).$

$r + EF = 2{,}102$ . . . log. 3.322633
$R + r = 2{,}586$ . . . log. 3.412629
Cos. B, 35° 38′ 9.910004

$B = 35° 38′.$
$A = B - N = 35° 38′ - 24° 30′ = 11° 08′.$



2. RECEDING FROM THE INTERSECTION OF TANGENTS.

Given the angle of divergence, N, the initial P. C. at G, the distance G H, and the radii R, *r*, to find the central angles A and B.

$GK = GH \times \tan. N.$
$KC = GC - GK = R - GK.$
LC or $EF = KC \times \cos. N$, the line C F being drawn parallel to L E.
$\cos. B = DF \div CD = (r + EF) \div (R + r).$
Angle A manifestly $= B + N.$

Example.

$N = 18^\circ 30'$, $GH = 920$, $R = 955$, $r = 819$.

$GK = GH \times \tan. N$.

$GH = 920$ . . . log. 2.963788
Tan. $18^\circ 30'$ . . . log. 9.524520
$GK = 307.8$ 2.488308

$KC = R - GK = 955 - 307.8 = 647.2$.

LC or $EF = KC \times \cos. N$.

$KC = 647.2$ . . . log. 2.811039
Cos. N, $18^\circ 30'$ . . . log. 9.976957
$EF = 613.8$ 2.787996

$\cos. B = (r + EF) \div (R + r)$.

$r + EF = 1{,}432.8$ . . . log. 3.156185
$R + r = 1{,}774$ . . . log. 3.248954
Cos. B, $36^\circ 08'$ 9.907231

$B = 36^\circ 08$
$A = B + N = 36^\circ 08' + 18^\circ 30' = 54^\circ 38'$.

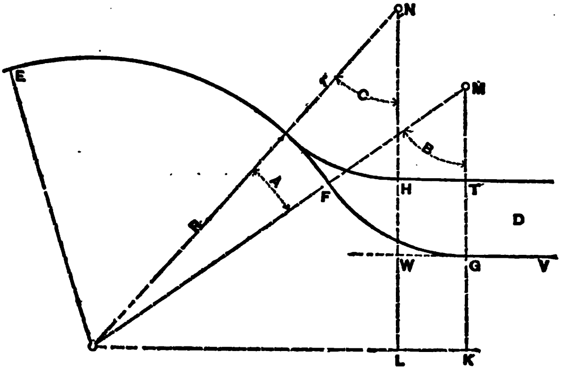
XLIV.

TO SHIFT A P. R. C. SO THAT THE TERMINAL TANGENT SHALL MERGE IN A GIVEN TANGENT PARALLEL THERETO.

Given the reversed curve E F G, ending in tangent G V: to find the angle of retreat, A, on the first branch, and the angle C of the second branch, ending in tangent H T, parallel to G V.

Measure the error $TG = D$, perpendicular to the terminal tangent.

In the figure, draw L K parallel to G V, and passing through centre of first branch.



$$
\begin{aligned}
\text{Then } MK &= (R + r) \times \cos. B.\\
NL &= (R + r) \times \cos. C.\\
WL &= GK.\\
NL &= r + D + GK.\\
MK &= r + GK.\\
NL - MK &= D.
\end{aligned}
$$

$$\therefore (R + r) \times \cos. C - (R + r) \times \cos. B = D.$$

$$\therefore (R + r) \times \cos. C = (R + r) \times \cos. B + D.$$

$$\therefore \cos. C = [(R + r) \times \cos. B + D] \div (R + r).$$

$$A = (90^\circ - C) - (90^\circ - B) = B - C.$$

Example.

$R = 1{,}433$, $r = 819$, $B = 34^\circ\ 20'$, $D = 94$.

$\cos. C = [(R + r) \cos. B + D] \div (R + r).$

$R + r = 2{,}252$ . . . log. 3.352568
$B = 34^\circ\ 20'$, *cos.* . . . log. 9.916859

$(R + r) \cos. B = 1{,}860$ 3.269427
Add D 94

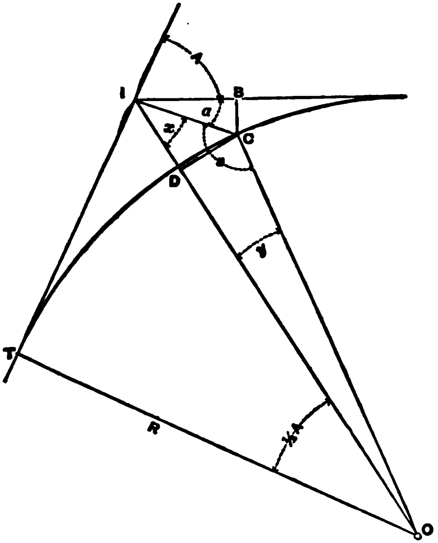
1,954 . . . log. 3.290925
$(R + r)$ . . . log. 3.352568

Cos. C, 29° 49′ 9.938357

$A = B - C = 34^\circ\ 20' - 29^\circ\ 49' = 4^\circ\ 31'.$

XLV.

TO PASS A CURVE THROUGH A FIXED POINT, THE ANGLE OF INTERSECTION BEING GIVEN.



Given the intersection angle, A, of two tangents, to find the radius, R, of a curve which shall pass through a point, C; the position of said point, with reference to the tangents or the point of intersection, being known.

1. By what data soever point C is located, they may be commuted by simple processes to the form shown in the figure; namely, the ordinate BC and the distance IC to apex. Call the angle BIC a, and complete the triangle ICO.

In this triangle, $x = \left(\frac{180 - \text{A}}{2}\right) - a = 90° - (\frac{1}{2}\text{A} + a)$.

Also, C O : I O :: *sin. x* : *sin. z*.

But $\text{CO} = \text{R}$; $\text{IO} = \frac{\text{R}}{\cos.\ \frac{1}{2}\text{A}}$. $\therefore \text{R} : \frac{\text{R}}{\cos.\ \frac{1}{2}\text{A}} :: \sin.\ x : \sin.\ z$.

Hence $\sin.\ z = \frac{\sin.\ x}{\cos.\ \frac{1}{2}\text{A}}$. The triangle I C O may then be solved, and the radius ascertained.

Example.

A = 40°, B C = 32 feet, I B = 80 feet.

Then B C ÷ I B = 32 ÷ 80 = 0.4 *nat. tan.* 21° 49′; and I C = B C ÷ *nat. sin.* 21° 49′ = 32 ÷ .372 = 86 feet.

Also, $x = 90° - (\frac{1}{2}\text{A} + a) = 90° - 41° 49' = 48° 11'$.

Next, *sin.* x, 48° 11′ . . . log. 9.872321
Divided by *cos.* ½ A, 20° . . . log. 9.972986
= *sin.* z, 127° 31′ . . . log. 9.899335

Or, since the sine of any angle is equal to the sine of its supplement, the supplement in this case, 52° 29′, may be taken directly from the logarithmic table, from which supplement deducting x, or 48° 11′, the remainder is the angle y = 4° 18′.

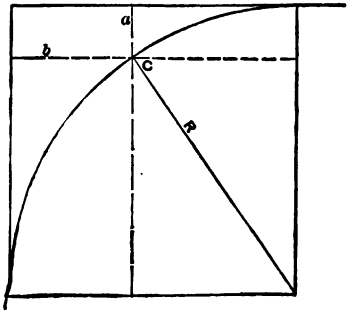
Finally, I C = 86 . . . log. 1.934498
Multiplied by *sin.* x, 48° 11′ . . . log. 9.872321
= C D . . . log. 1.806819
And C D divided by *sin.* y, 4° 18′ . . . log. 8.874938
= C O = R = say, 855 feet . . . log. 2.931881

2. In the case of a rectangular intersection, the solution is more simple. It is quite plain, from the figure, that—

$$\text{R}^2 = (\text{R} - a)^2 + (\text{R} - b)^2,$$

from which equation,

$$\text{R} = a + b + \sqrt{2ab}.$$



Example.

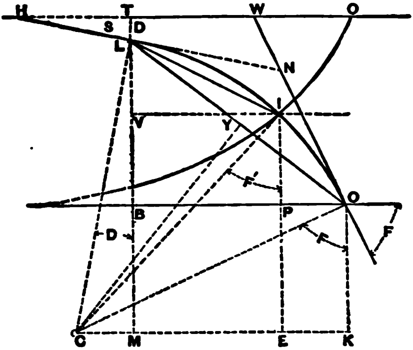
$$a = 40,\ b = 80.$$

$$\text{Then } R = 40 + 80 + \sqrt{6,400} = 200.$$

3. Cases of this kind are disposed of with great ease in the field by means of the curve-protractor.

XLVI.

FROGS AND SWITCHES.



TO FIND THE RADIUS OF A TURNOUT CURVE, THE FROG ANGLES, AND THE DISTANCES FROM THE TOE OF SWITCH TO THE FROG POINTS.

1. Draw the figure as in margin, C being the centre of the turnout curve, C K parallel to main track, and O K, I E, L M, perpendicular to it. Call the angle of the frogs at O, F; that of the intermediate frog at I, 2 F′; the throw of the switch-rail for single turnout, D; its angle with main track, S; the gauge of the track, G; and radius of outer rail, R.

2. Usually the length and throw of switch-rail and the angles of the frogs at O are given. In that case, to find R, F′, and the distances L O, L I, reason thus:—

3. The angle HNW, between the line of the switch-rail prolonged and a tangent to turnout curve at frog point O, $= NOP - NHW = F - S$. The angle NOL or NLO, between chord and tangent, = half the intersection angle $HNW = \frac{1}{2}(F - S)$. The angle $NOB = NOL + LOB$. But NOL is seen to be $= \frac{1}{2}(F - S)$, and $NOB = F$; then $LOB = NOB - NOL = F - \frac{1}{2}(F - S) = \frac{1}{2}(F + S)$. The distance LO, from toe of switch to point of main frog, $= LB \div$ *sin.* $LOB = (G - D) \div$ *sin.* $\frac{1}{2}(F + S)$.

4. Again: the angle $LCY = NLO = \frac{1}{2}(F - S)$; $LY = \frac{1}{2} LO = \frac{1}{2}(G - D) \div$ *sin.* $\frac{1}{2}(F + S)$. $LY \div$ *sin.* $LCY = LC$; i.e., $[\frac{1}{2}(G - D) \div$ *sin.* $\frac{1}{2}(F + S)] \div$ *sin.* $\frac{1}{2}(F - S) = R$.

5. R may be found otherwise, as follows:—

$OK = OC$ *cos.* $KOC = R$ *cos.* F; $LM = LC$ *cos.* $CLM = R$ *cos.* S; $LM - OK = LB$; i.e., R (*cos.* S — *cos.* F) $= (G - D)$. Hence $R = (G - D) \div$ (*nat. cos.* S — *nat. cos.* F).

6. If R be known, to find F. This equation gives *nat. cos.* F = *nat. cos.* $S - [(G - D) \div R]$.

7. To find the angle, $2F'$, of the middle frog at I.

$IE = IP + PE$ or OK; i.e., R *cos.* $F' = \frac{1}{2} G + R$ *cos.* F. Hence *nat. cos.* F' = *nat. cos.* $F + (\frac{1}{2} G \div R)$.

8. The angle LIV, by similar reasoning to that used in relation to LOB, is found to be $= \frac{1}{2}(F' + S)$. The distance LI, from toe of switch to point of middle frog, $= LV \div$ *sin.* $LIV = (\frac{1}{2} G - D) \div$ *sin.* $\frac{1}{2}(F' + S)$.

The preceding formulas translate into the following—

RULES FOR FROGS AND SWITCHES.

9. *To find the Angle of Switch-Rail with Main Track.*

Divide its throw, in decimals, by its length: the quotient will be the natural sine of the angle sought.

10. *To find the Distance from Toe of Switch to Point of Main Frog.*

Subtract the throw of switch-rail from the gauge of track, both in decimals; call the remainder *a*. Add together the angle of switch-rail with main track and the angle of the main frog; find the natural sine of half this sum, and call it *b*. Divide *a* by *b*: the quotient will be the distance *sought.*

11. *To find the Radius of Outer Rail of Turnout Curve.*

Subtract the throw of switch-rail from the gauge of track, both in decimals; call the remainder *a*. Subtract the natural cosine of the main frog angle from the natural cosine of the switch-rail angle; call the remainder *b*. Divide *a* by *b*: the quotient will be radius.

12. *To find the Main Frog Angle, the Radius of the Outer Rail being known.*

Call the natural cosine of the switch-rail angle *a*. Subtract the throw of switch-rail from the gauge of track, both in decimals. Divide the remainder by radius; call the quotient *b*. Subtract *b* from *a*: the remainder will be the natural cosine of the main frog angle.

13. *To find the Angle of the Middle Frog, in the Case of a Double Turnout.*

Call the natural cosine of the main frog angle *a*. Divide half the gauge of track by the radius of outer rail of turnout curve; call the quotient *b*. Add *a* and *b* together. Their sum is the natural cosine of half the middle frog angle.

14. *To find the Distance from Toe of Switch to Point of Middle Frog.*

Subtract the throw of switch-rail from half the gauge of track, both in decimals; call the remainder *a*. Add together the switch-rail angle and half the middle frog angle. Find the natural sine of half this sum; call said natural sine *b*. Divide *a* by *b*: the quotient will be the distance sought.

15. The use of logarithms will be found convenient in working these rules.

Examples.

16. Switch-rail, 18 feet; throw, 5 inches = 0.42 feet; frog angle, 5° 44′; gauge, 4.71 feet.

$\textit{Sin.}\ S = 0.42 \div 18 = .02334 = \textit{sin.}\ 1^\circ\ 20'$.

$LO = (G - D) \div \textit{sin.}\ \frac{1}{2}(F + S) = (4.71 - 0.42) \div \textit{sin.}\ 3^\circ\ 32' = 4.29 \div 0.0616 = 69.64$ feet.

$R = (G - D) \div (\textit{nat. cos.}\ S - \textit{nat. cos.}\ F) = 4.29 \div 0.00473 = 907$ feet.

$\textit{Nat. cos.}\ F' = \textit{nat. cos.}\ F + (\frac{1}{2} G \div R) = 0.995 + (2.354 \div$

907) = 0.99759 = *cos.* $3° 58\frac{1}{2}'$. Hence the angle of the middle frog $= 2\ F' = 7° 57'$.

$LI = (\frac{1}{2}\ G - D) \div$ *sin.* $\frac{1}{2}\ (F' + S) = (2.354 - 0.42) \div$ *sin.* $\frac{1}{2}\ (3° 58\frac{1}{2}' + 1° 20') = 1.934 \div 0.0463 = 41.8$ feet.

17. In ordinary practice, frogs may be located with sufficient exactness by the following rules, deduced from the congruity of triangles. Great nicety in their location is not necessary. The important thing in practice is to lay the turnout curve so that the approach to the frog shall be fair and regular. How trackmen may do this without the use of instruments, in a very simple way, will be shown hereafter. Not that frogs may be set hap-hazard, and the approaches forced to fit: they ought to be nearly where they mathematically belong, and they can be thus placed by means of the rules subjoined.

18. Let N stand for the number of the frog;
L the length of switch-rail in feet;
F the distance from toe of outer switch-rail to point of frog in feet.

Then, for standard gauge, 4 feet 8½ inches, straight switch-rail, and 5 inches throw of switch.

$$F = \frac{8.6\ L\ N}{L + 0.42\ N}.$$

The above may be written roundly as a rule thus: —

Multiply the length of switch-rail in feet by the number of the frog, and set down the product. Multiply that product by 8½, and call the result A. Next add together the length of switch-rail in feet and two-fifths of the frog number; call the sum B. Then divide A by B, and the quotient will be the distance in feet from toe of outer switch-rail to point of frog.

Example.

Switch-rail, 20 feet long; frog, No. 9.

Length of switch-rail	20
Multiplied by frog number	9
Product	180
Multiplied by	8½
	1,530 = A.
Length of switch-rail	20
Added to ⅖ frog No. 9	3.6
	23.6 = B.

A divided by B = 1,530 divided by 23.6 = 64,8 feet, the frog distance; say, 65 feet.

19. If the switch-rail be curved, the formula would stand thus:—

$$F = \frac{8.6\ L\ N}{L + 0.84\ N}.$$

Which may be made a written rule as follows:—

Multiply the length of switch-rail in feet by the number of the frog, and their product by 8½; call the result A. Add together the length of switch-rail in feet and four-fifths of the frog number; call the sum B. Then divide A by B, and the quotient will be the distance from toe of outer switch-rail to point of frog in feet.

20. The foregoing rules are applicable to turnouts from curves, as well as from straight lines.

21. To find the radius of outer rail of a turnout curve from straight track. Data same as in previous rules for frogs; R the required radius in feet.

If the switch-rail be straight, $R = \frac{8.6\ L^2\ N^2}{L^2 - 0.17\ N^2}$.

If the switch-rail be curved, $R = \frac{8.6\ L^2\ N^2}{L^2 - 0.68\ N^2}$.

22. To find the radius of the outer rail of a turnout curve from curved track, proceed thus:—

First find the radius as for a turnout from straight track by the preceding rule; call it, as before, R. Call the radius of the main track R_2, and the required radius of turnout curve r.

Then, if the turnout be towards the concave side of main track,—

$$r = \frac{R_2 \times R}{R_2 + R}.$$

If the turnout be towards the convex side of main track,—

$$r = \frac{R_2 \times R}{R_2 - R}.$$

More explicitly, in the first case, r is equal to the product of the other radii divided by their sum; and, in the second case, *r is equal to the* product of the other radii divided by their *difference.*

23. The angle of a frog is equal to 3,440′ divided by the frog number.

24. To find the frog distances and radii for a three-foot gauge, find them by the preceding rules for standard gauge, and take five-eighths of the result, using a switch-rail reduced in like measure.

For a metre gauge, take seven-tenths of the result, using a switch-rail reduced in like measure.

Or these radii and distances may be found from the appended tables for standard gauge by pro-rating as above.

25. Three frog patterns are enough for general service. They should be so proportioned, that, taken in couples, the less may fit as middle frogs on double turnouts. Numbers 5½, 7½, and 10½ make an excellent suit; numbers 5, 7, and 9½ also answer very well.

26. At the terminal stations, and about the shops of busy roads, patterns necessarily multiply. The better way in such cases is to plot the situation to a large scale, and to take the required distances and angles from the drawing.

TURNOUT TABLE. — SWITCH-RAILS, STRAIGHT; GAUGE OF TRACK, 4 FEET 8½ INCHES; THROW OF SWITCH-RAIL, 5 INCHES.

		MAIN FROG NUMBERS AND ANGLES.																	
		4 14° 20′	4½ 12° 44′	5 11° 28′	5½ 10° 21′	6 9° 33′	6½ 8° 52′	7 8° 11′	7½ 7° 41′	8 7° 10′	8½ 6° 46′	9 6° 22′	9½ 6° 03′	10 5° 44′	10½ 5° 28′	11 5° 13′	11½ 5° 00′	12 4° 47′
	Main frog dist.	30.2	33.5	36.6	39.9	42.7	45.3	48.4	50.9	53.7	56.1	58.8	61.3	63.6	65.9	68.3	70.3	72.7
Switch-rail, 12 ft	Rad. outer rail.	140.6	178.9	221.8	274.9	325.0	378.4	450.2	515.0	595.8	675.0	772.0	870.0	976.7	1,089	1,224	1,342	1,506
Do. angle, 2° 00′	Mid. frog dist.	19.0	20.9	22.6	24.4	25.8	27.3	28.9	30.1	31.6	32.8	34.0	35.1	36.2	37.2	38.3	39.2	40.1
	Mid. frog angle.	19° 28′	17° 20′	15° 41′	14° 14′	13° 12′	12° 16′	11° 24′	10° 46′	10° 04′	9° 34′	9° 03′	8° 40′	8° 15′	7° 55′	7° 38′	7° 21′	7° 05′
	Main frog dist.	31.2	34.6	38.0	41.6	44.6	47.5	50.9	53.7	56.8	59.5	62.6	65.3	68.0	70.0	73.4	75.7	78.5
Switch-rail, 16 ft	Rad. outer rail.	139.4	176.9	218.8	270.3	318.6	369.7	438.0	499.2	575.0	648.0	737.0	826.0	921.0	1,020	1,137	1,263	1,377
Do. angle, 1° 30′	Mid. frog dist.	19.9	22.0	24.0	26.0	27.8	29.4	31.3	32.8	34.5	35.9	37.4	38.7	40.4	41.6	43.0	43.8	45.3
	Mid. frog angle.	19° 22′	17° 14′	15° 34′	14° 06′	13° 02′	12° 06′	11° 14′	10° 34′	9° 54′	9° 22′	8° 51′	8° 27′	8° 01′	7° 40′	7° 22′	7° 09′	6° 49′
	Main frog dist.	31.8	35.4	38.9	42.7	45.9	48.9	52.6	55.5	58.8	61.8	65.0	68.0	71.0	73.8	76.9	79.4	82.5
Switch-rail, 20 ft	Rad. outer rail.	138.8	176.0	217.4	268.2	315.7	365.8	432.6	492.1	565.0	636.0	721.0	807.0	897.0	992.0	1,102	1,196	1.325
Do. angle, 1° 12′	Mid. frog dist.	20.5	22.7	24.8	27.1	28.9	30.8	32.8	34.5	36.5	38.1	39.9	41.4	43.1	44.4	45.9	47.6	49.0
	Mid. frog angle.	19° 19′	17° 10′	15° 30′	14° 02′	12° 58′	12° 02′	11° 10′	10° 30′	9° 47′	9° 16′	8° 44′	8° 21′	7° 54′	7° 34′	7° 15′	6° 57′	6° 41′
	Main frog dist.	32.2	35.9	39.5	43.5	46.8	49.9	53.7	56.8	60.3	63.4	66 8	70.0	73.1	76.1	79-4	82.0	85.3
Switch-rail, 24 ft	Rad. outer rail.	138.5	175.6	216.6	267.1	314.2	363.7	429.6	488.4	560.2	630.0	713.5	796.5	885.0	976.2	1,083	1,175	1,298
Do. angle, 1° 00′	Mid. frog dist.	20.9	23.2	25.5	27.8	29.8	31.7	33.9	35.6	37.9	39.7	41.6	43.3	45.2	46.8	48.3	49.9	51.4
	Mid. frog angle.	19° 17′	17° 09′	15° 28′	14° 00′	12° 56′	12° 00′	11° 06′	10° 28′	9° 44′	9° 14′	8° 41′	8° 17′	7° 50′	7° 30′	7° 12′	6° 54′	6° 37′
	Main frog dist.	32.6	36.4	40.1	44.2	47.7	50.9	54.9	58.1	61.8	65.0	68.7	72.0	75.3	78.5	82.0	84.8	88.4
Switch-rail, 30 ft	Rad. outer rail.	138.3	175.2	215.6	266.2	312.9	362.0	427.3	485.3	556.2	624.8	707.0	788.5	875.0	964.2	1,068	1,157	1,276
Do. angle, 0° 48′	Mid. frog dist.	21.3	23.7	26.1	28.6	30.6	32.8	34.2	37.0	39.3	41.3	43.3	45.2	47.3	49.0	50.9	52.9	54.2
	Mid. frog angle.	19° 16′	17° 08′	15° 25′	13° 58′	12° 54′	11° 58′	11° 04′	10° 25′	9° 42′	9° 10′	8° 30′	8° 14′	7° 47′	7° 27′	7° 09′	6° 50′	6° 34′

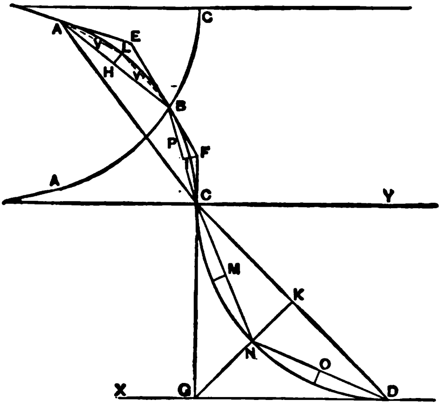
TURNOUT TABLE.—SWITCH-RAILS, CURVED; GAUGE OF TRACK, 4 FEET 8½ INCHES; THROW OF SWITCH-RAIL, 5 INCHES.

		MAIN FROG NUMBERS AND ANGLES.																
		4 14° 20′	4½ 12° 44′	5 11° 28′	5½ 10° 21′	6 9° 33′	6½ 8° 52′	7 8° 11′	7½ 7° 41′	8 7° 10′	8½ 6° 46′	9 6° 22′	9½ 6° 03′	10 5° 44′	10½ 5° 28′	11 5° 13′	11½ 5° 00′	12 4° 47′
Switch-rail, L'gth. 12 ft. Ang. 4° 00′. Rad. 171.9.	Main frog dist.	26.9	29.5	31.9	34.4	36.4	38.3	40.4	42.2	44.1	45.8	47.5	49.0	50.6	52.0	53.4	54.7	56.3
	Rad. outer rail.	149.6	193.7	244.9	310.2	375.8	451.1	553.9	656.1	798.2	947.3	1,160	1,370	1,672	2,032	2,516	3,135	4,117
	Mid. frog dist.	15.8	17.1	18.2	19.3	20.1	20.9	21.7	22.3	23.0	23.6	24.1	24.6	25.1	25.5	25.9	26.2	26.5
	Mid. frog angle.	20° 08′	18° 06′	16° 30′	15° 06′	14° 08′	13° 18′	12° 30′	11° 54′	11° 18′	10° 52′	10° 26′	10° 04′	9° 42′	9° 26′	9° 10′	8° 58′	8° 45′
Switch-rail, L'gth. 16 ft. Ang. 3° 00′. Rad. 312.7.	Main frog dist.	28.5	31.4	34.1	36.9	39.3	41.5	44.0	46.1	48.5	50.4	52.6	54.4	56.4	58.1	59.9	61.5	63.3
	Rad. outer rail.	144.2	184.8	230.8	288.1	343.7	405.7	487.1	564.3	666.2	767.0	894.7	1,022	1,182	1,351	1,549	1,762	2,032
	Mid. frog dist.	17.29	18.8	20.2	21.6	22.7	23.8	24.9	25.8	26.8	27.6	28.4	29.1	29.8	30.4	31.1	31.6	32.2
	Mid. frog angle.	19° 44′	17° 40′	16° 02′	14° 36′	13° 34′	12° 42′	11° 52′	11° 14′	10° 36′	10° 08′	9° 38′	9° 16′	8° 54′	8° 36′	8° 18′	8° 03′	7° 48′
Switch-rail, L'gth. 20 ft. Ang. 2° 24′. Rad. 477.5.	Main frog dist.	29.5	32.6	35.6	38.7	41.3	43.7	46.5	48.8	51.5	53.7	56.2	59.1	60.5	62.6	64.6	66.7	68.5
	Rad. outer rail.	141.9	181.0	224.9	278.9	330.7	387.6	461.3	529.8	618.9	704.9	811.1	914.7	1,040	1,169	1,315	1,469	1,648
	Mid. frog dist.	18.25	20.0	21.6	23.2	24.6	25.8	27.2	28.2	29.5	30.5	31.6	32.5	33.5	34.3	35.1	35.8	36.6
	Mid. frog angle.	19° 34′	17° 28′	15° 48′	14° 21′	13° 18′	12° 26′	11° 34′	10° 56′	10° 16′	9° 46′	9° 16′	8° 53′	8° 29′	8° 10′	7° 51′	7° 37′	7° 20′
Switch-rail, L'gth. 24 ft. Ang. 2° 00′. Rad. 687.6.	Main frog dist.	30.2	33.5	36.6	39.9	42.7	45.3	48.4	50.9	53.7	56.2	58.8	61.2	63.6	65.8	68.2	70.3	72.6
	Rad. outer rail.	149.6	178.9	221.8	274.0	324.0	378.4	448.3	513.0	595.8	675.2	772.1	865.2	976.8	1,090	1,215	1,343	1,494
	Mid. frog dist.	18.9	20.8	22.6	24.4	25.9	27.3	28.9	30.2	31.6	32.8	34.1	35.1	36.3	37.3	38.3	39,1	40.1
	Mid. frog angle.	19° 28′	17° 20′	15° 41′	14° 12′	13° 10′	12° 16′	11° 23′	10° 44′	10° 04′	9° 34′	9° 03′	8° 39′	8° 15′	7° 55′	7° 36′	7° 21′	7° 04′
Switch-rail, L'gth. 30 ft. Ang. 1° 36′. Rad. 1,074.	Main frog dist.	31.0	34.4	37.7	41.2	44.2	47.1	50.3	53.0	56.2	58.8	61.8	64.4	67.1	69.6	72.2	74.6	77.1
	Rad. outer rail.	139.6	177.3	219.3	270.3	318.6	371.2	438.3	499.7	578.1	652.7	742.8	828.3	930.3	1,032	1,144	1,256	1,388
	Mid. frog dist.	19.7	21.7	23.7	25.7	27.4	29.0	30.8	32.2	33.9	35.3	36.8	38.1	39.5	40.7	41.9	43.0	44.1
	Mid. frog angle.	19° 23′	17° 15′	15° 35′	14° 06′	13° 02′	12° 08′	11° 14′	10° 36′	9° 55′	9° 24′	8° 53′	8° 28′	8° 03′	7° 43′	7° 24′	7° 08′	6° 52′

XLVII.

TO LOCATE A TURNOUT.

1. Let the heavy parallels in the figure represent the rails of the main track.



2. Stick a pin or drive a spike at A, the toe of switch, at a distance from the gauge side of the main-track rail equal to the throw of the switch-rail. Lay off the distances A C and A B (if a double turnout), taken from the foregoing tables, and place the frogs C and B, or mark those points. Stretch the cord from A to B, and from B to C. Mark the middle points of those stretches at H and P. Catch the cord at H with your forefinger, and pull it outwards until your finger, at E, lines with the switch-rail, and also with the right gauge side of frog B. Stick a pin at L, half-way between H and E. Let the cord spring in against L, so that it shall stretch straight from A to L, and from L to B. Opposite the middle points, V, of those stretches, stick pins on the outside at a distance from the cord equal to one-quarter of H L. In like manner, catch the cord at P, the point midway between B and C; stretch it to F, in line with the gauge sides of the frogs; and stick a pin at I, half-way between P and F.

3. Next lay off the proposed line of the near rail of the side track, X D. Mark the point G on that line where the range of the proper gauge side of frog C strikes it. Measure C G. Set off G D, equal to C G, along the side-track line, and drive a pin at D. Stretch the cord from C to D. Mark the middle point of it at K, and drive a pin at N, half-way between K and G. Stretch the cord from C to N, and from N to D. Stick pins outside the middle points, M and O, of those stretches at a distance from those points, M and O, equal to one-quarter of K N.

4. These three sets of pins will fix the line of one rail of the turnout. The corresponding rail of a double turnout can be laid off from them, if required, by symmetrical measurements.

5. In the case of a single turnout, stretch the cord from the toe of switch, as above, to the point of frog, located by the foregoing tables; catch it at the middle, and pull it outwards to a point in range with the line of the switch-rail in one direction, and the gauge side of frog in the other direction. Half-way between that point and the middle of the cord, when straight, stick a pin. Measure that half-way distance, and divide it by 4; call the quotient the "quarter-distance." Stretch the cord from the pin just set to the toe of switch in one direction, and to the point of frog in the other. Outside the middle points of these short stretches, lay off the "quarter-distance," as above found, and stick two other pins. These three pins will sufficiently mark the line of the outer rail of the turnout.

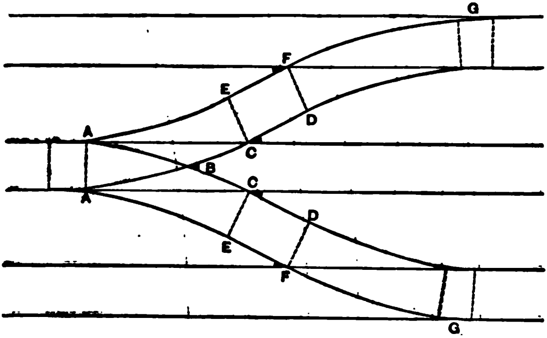
6. The same methods will apply in practice to turnouts from curves. In the latter case, the distance C G is to be calculated as follows: —

Multiply the distance Y D, between the nearest rails of the parallel tracks, by the number of the frog, taken from the foregoing table. Thus, on the full gauge, with a space between tracks of 7 feet and a No. 6 frog, the distance C G would be 7 × 6 = 42 feet. Lay off C G, in range of the gauge side of the frog, and stick a pin at G. Measure out G D, equal to C G, and set another pin at D, making D Y the proper distance between tracks. Then stretch the cord from D to C, and proceed to stake off the curve C N D, as above directed.

XLVIII.

CROSSINGS ON STRAIGHT LINES.

1. Having located frogs B and C by the preceding methods, stretch the cord any convenient distance, C D, in the range of the outer gauge side of the frog C. Set off E F parallel to C D, and distant the gauge-width from it. The intersection of said parallel at F with the near rail of the side track marks the spot for point of side-track frog; the curve F G, thence to toe of switch, corresponds to A C on the main track, and may be staked out in like manner.



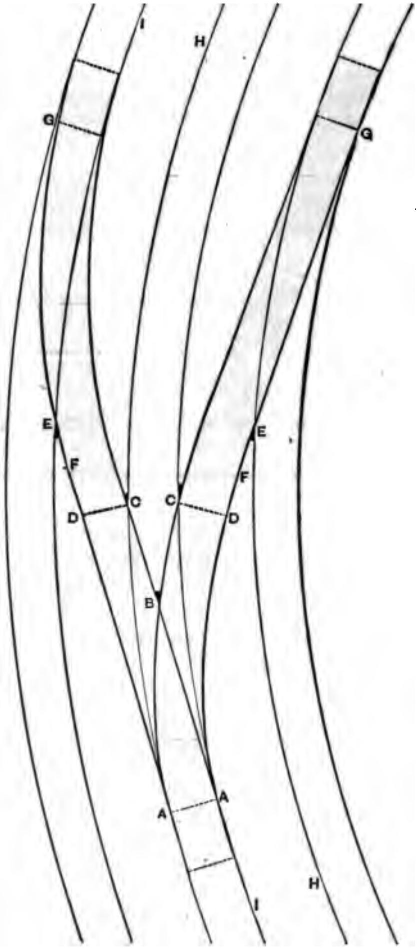
XLIX.

CROSSINGS ON CURVES.

1. Having located frogs B and C by the preceding methods, set off the width of gauge, C D, from point of frog C, and square to its outer gauge side. Stick a pin at D.

2. Next calculate the distance D E to the point of side-track frog as follows: Subtract the gauge of track from the dis-

tance, H I, between the gauge sides of the nearest rails of the main and side tracks; multiply the remainder by the number of the frog, taken from foregoing tables. The product will be *the distance from D* to the point of side-track frog at E.



3. Suppose, for example, the gauge sides of the nearest rails of the main and side tracks are 6 feet 6 inches asunder; gauge of track, 4 feet 8½ inches; frog, a No. 9. Reducing inches to decimals, we have then the distance between tracks 6.5 feet, less the gauge, 4.7 feet, = 1.8 feet; and 1.8 multiplied by 9, the number of the frog, gives 16.2 feet for the distance D E. The proper spring will be given to rail D E on the ground; and curve E G, from frog to toe of side-track switch, will be staked off as directed in the section on turnouts.

L.

ELEVATION OF THE OUTER RAIL ON CURVES.

1. Great precision in this adjustment is unattainable, owing to differences in the speed of trains and to the cost of track-maintenance, if it were attempted. The annexed table will be found convenient in practice. It has been calculated by the following simple rule: —

2. Divide the speed in miles per hour by 10; multiply the square of the quotient by the degree of curve. The product is the elevation in sixteenths of an inch for full gauge of 4 feet 8½ inches. Take two-thirds of it for 3-feet narrow gauge.

3. Molesworth gives the following formula for determining the elevation of the outer rail with any gauge: —

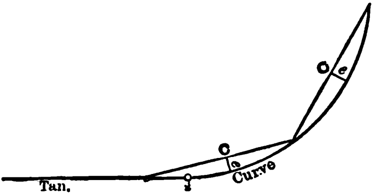
V = greatest velocity of trains in feet per second.

G = gauge of railway in feet.

C = length of chord whose middle ordinate will give the required elevation.

Then $C = \frac{1}{2} V \sqrt{G}$.

A modification of this formula gives the following approximate rules: —



To fix the elevation of the outer rail on the standard gauge of 4 feet 8½ inches, multiply the speed of trains in miles per hour by 5, and divide the product by 3. This will give the length of tape, C, to stretch on the gauge side of the outer rail; and the distance, *e*, from the middle of the tape to the gauge side of the rail, will be the proper elevation.

For gauge of *one metre*, = 3.28 feet, make C equal to one and one-third times the speed of trains in miles per hour.

For 3-feet gauge, make C equal to one and one-fourth times the speed of trains in miles per hour.

TABLE OF ELEVATIONS FOR OUTER RAIL ON CURVES.

DEGREE OF CURVE.	SPEED IN MILES PER HOUR.								DEGREE OF CURVE.
	10		20		30		40		
	ELEVATION OF OUTER RAIL IN INCHES AND FRACTIONS.								
	Full Gauge, 4 ft. 8½ in.	Nar. Gauge, 3 feet.	Full Gauge, 4 ft. 8½ in.	Nar. Gauge, 3 feet.	Full Gauge, 4 ft. 8½ in.	Nar. Gauge, 3 feet.	Full Gauge, 4 ft. 8½ in.	Nar. Gauge, 3 feet.	
1°	1-16	..	1-4	3-16	9-16	3-8	1	11-16	1°
2°	1-8	..	1-2	5-16	1 1-8	3-4	2	1 5-16	2°
3°	3-16	1-8	3-4	1-2	1 11-16	1 1-8	3	2	3°
4°	1-4	..	1	11-16	2 1-4	1 1-2	4	2 11-16	4°
5°	5-16	..	1 1-4	13-16	2 13-16	1 7-8	5	3 5-16	5°
6°	3-8	1-4	1 1-2	1	3 3-8	2 1-4	6	4	6°
7°	7-16	..	1 3-4	1 3-16	3 15-16	2 5-8	7	4 11-16	7°
8°	1-2	..	2	1 5-16	4 1-2	3	8	5 5-16	8°
9°	9-16	3-8	2 1-4	1 1-2	5 1-16	3 3-8	9	6	9°
10°	5-8	..	2 1-2	1 11-16	5 10-16	3 3-4	10	6 11-16	10°
11°	11-16	..	2 3-4	1 13-16	6 3-16	4 1-8	11	7 5-16	11°
12°	3-4	1-2	3	2	6 3-4	4 1-2	12	8	12°
13°	13-16	..	3 1-4	2 3-16	7 5-16	4 7-8	13	8 11-16	13°
14°	7-8	..	3 1-2	2 5-16	7 14-16	5 1-4	14	9 5-16	14°
15°	15-16	5-8	3 3-4	2 1-2	8 7-16	5 5-8	15	10	15°
16°	1	..	4	2 11-16	9	6	16	10 11-16	16°

LI.

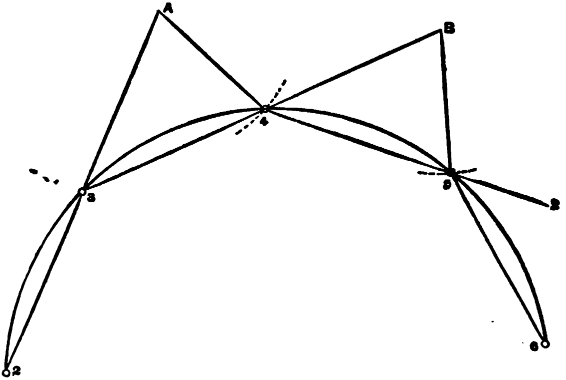
TRACKMEN'S TABLE OF CURVES AND SPRING OF RAILS.

DEGREE OF CURVE.	DEFLECTION DISTANCES IN FEET AND INCHES.		MIDDLE ORDINATES IN INCHES AND FRACTIONS, THE LENGTH OF CHORD BEING					LENGTH OF CHORD IN FEET AND INCHES, WITH A MIDDLE ORDINATE EQUAL TO GAUGE OF TRACK.				DEGREE OF CURVE.
			100 Feet.	50 Feet.	30 Feet.	24 Feet.	20 Feet.	Full Gauge, 4 feet 8½ inches.		Narrow Gauge, 3 feet.		
	Ft.	In.						Ft.	In.	Ft	In.	
1°	1	9	2 1-2	5-8	1-4	1-8	1-8	463	5	370	0	1°
2°	3	6	5 1-4	1 1-4	1-2	5-16	3-16	328	5	261	10	2°
3°	5	3	8	2	11-16	7-16	5-16	266	2	214	7	3°
4°	7	0	10 1-2	2 5-8	15-16	5-8	3-8	232	0	185	1	4°
5°	8	9	13	3 1-4	1 3-16	3-4	1-2	207	7	165	11	5°
6°	10	5 1-2	15 3-4	4	1 7-16	7-8	5-8	189	8	151	4	6°
7°	12	2 1-2	18 1-4	4 5-8	1 5-8	1 1-16	3-4	175	6	140	2	7°
8°	13	11 1-2	21	5 1-4	1 7-8	1 3-16	13-16	164	1	131	0	8°
9°	15	8 1-3	23 1-2	5 7-8	2 1-8	1 3-8	15-16	154	10	123	7	9°
10°	17	5	26 1-4	6 1-2	2 3-8	1 1-2	1 1-16	146	5	117	2	10°
11°	19	2	29	7 1-4	2 9-16	1 5-8	1 1-8	140	0	111	10	11°
12°	20	11	31 1-2	7 7-8	2 13-16	1 13-16	1 1-4	134	1	107	2	12°
13°	22	9	34	8 1-2	3 1-16	1 15-16	1 1-2	129	0	102	11	13°
14°	24	4 1-2	36 3-4	9 1-4	3 5-16	2 1-8	1 5-8	124	1	99	2	14°
15°	26	1 1-4	39 1-4	9 7-8	3 1-2	2 1-4	1 3-4	120	0	96	0	15°
16°	27	10	42	10 1-2	3 3-4	2 7-16	1 7-8	116	2	92	11	16°
17°	29	6 3-4	44 1-2	11 1-8	4	2 9-16	1 15-16	112	10	90	1	17°
18°	31	3 1-2	47 1-4	11 7-8	4 1-4	2 11-16	2 1-16	109	7	87	6	18°
19°	33	0	49 3-4	12 1-2	4 1-2	2 7-8	2 3-16	106	8	85	2	19°
20°	34	9	52 1-2	13 1-8	4 9-16	3	2 5-16	104	0	84	11	20°

EXPLANATION OF THE FOREGOING TABLE.

Columns 1 and 10 give the degree of curve.

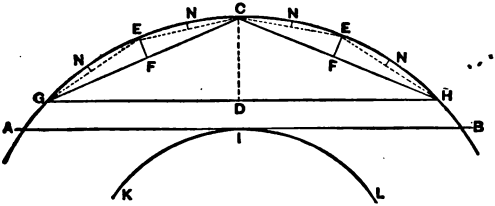
The use of column 2, containing the deflection distances, may be illustrated thus: Suppose stakes 4, 5, and 6 to be missing from a 3-degree curve, and that stakes 2 and 3 are still standing 100 feet apart. To replace the missing stakes, proceed as follows: Measure 100 feet from 3 to A, and make a mark at A exactly in range with 2 and 3. Find, in column 2 of the table, the deflection distance for a 3-degree curve, which is seen to be 5 feet 3 inches. Hold one end of the tape at A, and, stretching 5 feet 3 inches towards 4, nearly square to the range A–3, make a scratch on the ground three or four feet long, swinging the tape around A as a centre. Next lay off 100 feet from stake 3 to the scratch; where the end of that measurement strikes it, is the place for stake 4. By measuring 100 feet out to B on the range 3–4, and proceeding in like manner, stake 5 may be set; and so on.



3. If the centre line is already staked for track at points 100 feet asunder, and the degree of curve is wanted, range out the straight line between stakes, as above, to A or B, and measure across from those marks to the neighboring location-stake. Suppose the distance B–5, for example, to be 8 feet 9 inches. Referring, then, to column 2 of the table, we find that *deflection distance* to indicate a 5-degree curve. If the distance

proved to be 4 feet 4 inches, we should soon discover that that distance was about half-way between 3 feet 6 inches and 5 feet 3 inches, the nearest numbers in the table corresponding respectively to a 2-degree and a 3-degree curve, and showing the located line to be a 2½-degree curve.

4. Let A C B in the figure, which is drawn very much out of proportion in order to make the subject clear, represent the centre line of a curve. Suppose G H to be a chord 100 feet long, and G C or C H to be a chord 50 feet long. Then column 3 in the table gives the distance, C D, from the middle of the 100-feet chord to the rail, and column 4 gives the distance, E F, from the middle of the 50-feet chord to the rail, for the different degrees of curve. By the aid of these columns, pins can be set 25 feet apart on a curve where the location-stakes are 100 feet apart. Thus, for a 3-degree curve, C D is 8 inches, and E F 2 inches. If pins were wanted at the half-way marks, N, their distance from the dotted short chords would be one-quarter of E F. It must be an uncommon case, however, that calls for stakes closer together than 25 feet.



5. Columns 5, 6, and 7 give the spring of rails of different lengths for the various degrees of curve.

6. Columns 8 and 9 give figures for finding the degree of curve, by simple measurement of a straight line on the track, as follows: Suppose A C B and K I L to represent the rails of a curving track. From any point A, on the outer rail, sight across to a point B, on the same rail, along a line just touching the inner rail at I. Measure from A to B, and seek the distance in column 8 or 9, according to the gauge of track. If the distance, for example, measured 232 feet on the full gauge, then the curve would be a 4-degree curve; if 249 feet, then it would indicate a 3½-degree curve, for the reason that the

measured distance falls half-way between the distances corresponding to a 3-degree and a 4-degree curve respectively.

7. The rate of curve can be found also very nearly by means of column 3. To do so, stretch a straight line, 100 feet long, between points on either rail; for, though they seem very different in the figure, the two rails of a track have practically the same curvature. Measure from the middle of the line across to the gauge side of the rail, and seek the measured distance in column 3: opposite to it, in column 1, will be found the degree of curve.

8. If, in any case, the exact figures sought are not found in the table, take out the next figure less and the next greater. Subtract one from the other, and divide the remainder by 4. Add the fourth part of the difference between them, thus determined, to the smaller number, and compare the sum with the number sought. If still too small, add another fourth part; and so on until the distance or the degree is ascertained to within a quarter part.

9. Suppose, for instance, a deflection distance measures 5 feet 7 inches. The nearest tabular numbers are 5 feet 3 inches and 7 feet. Their difference is 21 inches, one-fourth of which is 5¼ inches. Adding 5¼ inches to the smaller number, 5 feet 3 inches, gives 5 feet 8¼ inches, which indicates nearly enough a 3¼-degree curve. Again: if a measurement of 175 feet is sought in column 9, the track is seen at once, without calculation, to be a 4½-degree curve.

TABLES

TABLES OF THE TIMES OF CULMINATION AND OF ELONGATION OF THE POLE-STAR AND OF ITS AZIMUTH AT ELONGATION.

These tables are designed to facilitate the determination of a meridian line and of the magnetic declination (variation of the compass) by simple instrumental means (p. 44). For this purpose the tables are sufficiently accurate. They will also be found useful when preparing for or laying out work for a more refined determination of the astronomical azimuth and for the measures of the value of an eye-piece micrometer.

TABLE I.

MEAN LOCAL (ASTRONOMICAL) TIME, COUNTED FROM NOON AND FROM ZERO TO TWENTY-FOUR HOURS, OF THE CULMINATIONS AND ELONGATIONS OF POLARIS IN THE YEAR 1889. COMPUTED FOR LATITUDE 40° NORTH AND LONGITUDE 6 HOURS WEST FROM GREENWICH.

1889.

DATE.	E. ELONG.		UPPER CULM.		W. ELONG.		LOWER CULM.	
	h.	*m.*	*h.*	*m.*	*h.*	*m.*	*h.*	*m.*
Jan. 1	0	36.2	6	31.0	12	25.7	18	29.1
" 15	23	37.0	5	35.7	11	30.4	17	33.8
Feb. 1	22	29.9	4	28.6	10	23.3	16	26.7
" 15	21	34.6	3	33.3	9	28.1	15	31.4
March 1	20	39.4	2	38.1	8	32.8	14	36.2
" 15	19	44.4	1	43.1	7	37 7	13	41.1
April 1	18	37.4	0	36.0	6	30.7	12	34.1
" 15	17	42.4	23	37.1	5	35.7	11	39.0
May 1	16	30.5	22	34.2	4	32.9	10	36.1
" 15	15	44.6	21	39.3	3	38.0	9	41.2
June 1	14	37.9	20	32.7	2	31.3	8	34.6
" 15	13	43.0	19	37.8	1	36.4	7	39.7
July 1	12	40.4	18	35.2	0	33.8	6	37.1
" 15	11	45.5	17	40.3	23	35.0	5	42.2
Aug. 1	10	39.0	16	33 8	22	28.4	4	35.7
" 15	9	44.1	15	38.9	21	33.5	3	40.8
Sept. 1	8	37.5	14	32.3	20	26.9	2	34.2
" 15	7	42.6	13	37.4	19	32.0	1	39.3
Oct. 1	6	39.7	12	34.5	18	29.1	0	36.4
" 15	5	44.7	11	39.5	17	34.1	23	37.6
Nov. 1	4	37.9	10	32.7	16	27.3	22	30.8
" 15	3	42.7	9	37.5	15	32.2	21	35.6
Dec. 1	2	39.7	8	34.5	14	29.2	20	32.6
" 15	1	44.4	7	39.2	13	34.0	19	37.3

To refer the tabular times to any year subsequent to the tabular year (1889) add $0^{m}.33$ for every year.

To refer the tabular times, corrected as above, to any year in a quadrennium, observe the following rules:

For the first year after a leap-year the table is correct.

For the second year after a leap-year add $0^{m}.9$ to the tabular value.

For the third year after a leap-year add $1^{m}.7$ to the tabular value.

For leap-year and *before* March 1 add $2^{m}.6$ to the tabular value.

For leap-year from and after March 1 subtract $1^{m}.2$ from the tabular value.

To refer to any calendar day other than the 1st and 15th of each month, *subtract* $3^m.94$ for every day between it and the *preceding* tabular day, or *add* $3^m.94$ for every day between it and the *succeeding* tabular day.

The longitude correction will amount to $0^m.16$ for each hour.

To refer to any other than the tabular latitude, and between the limits of 25° and 50° North, *add* to the time of west elongation $0^m.13$ for every degree *South* of 40° and *subtract* from the time of west elongation $0^m.18$ for every degree *North* of 40°. Reverse these signs for corrections to times of east elongation.

Observe that the year 1900 is not a leap-year, and this must be kept in view when dealing with dates from and after March 1 of that year. The 20th century begins after the expiration of Dec. 31, 1900.

The deduced tabular times may be relied on to have no greater error than ± $0^m.3$.

Table II. below Lat. 24° is abridged from a table for each degree of latitude between 25° and 50° North, computed for this book by Mr. C. A. Schott, Asst. Supt. of the U. S. C. and G. Survey, with the mean declination of Polaris for each year. A closer result will be had by applying to the tabular values the following correction, which depends on the difference of the mean and the apparent places of the star:

FOR MIDDLE OF	LAT. 25°	LAT. 40°	LAT. 50°	FOR MIDDLE OF	LAT. 25°	LAT. 40°	LAT. 50°
Jan.	− 0′.3	− 0′.4	− 0′.4	July	+ 0′.2	+ 0′.3	+ 0′.3
Feb.	− 0 .3	− 0 .3	− 0 .4	Aug.	+ 0 .1	+ 0 .1	+ 0 .2
March	− 0 .1	− 0 .2	− 0 .2	Sept.	0 .0	− 0 .1	− 0 .1
April	0 .0	0 .0	0 .0	Oct.	− 0 .2	− 0 .3	− 0 .3
May	+ 0 .2	+ 0 .2	+ 0 .2	Nov.	− 0 .5	− 0 .6	− 0 .7
June	+ 0 .3	+ 0 .3	+ 0 .3	Dec.	− 0 .6	− 0 .8	− 0 .9

The deduced tabular azimuth, counted from the North, may generally be depended upon with no greater error than ± 0′.2.

In making the computation the mean places of Polaris were first accurately deduced from Newcomb's Catalogue of 1098 standard clock and zodiacal stars, Washington, 1881, for five equidistant epochs. From these fundamental places those for each year were readily found by interpolation.

Azimuth for latitudes less than 25° was reckoned by the author from the *data* for that degree.

TABLE II.

AZIMUTH OF POLARIS WHEN AT ELONGATION FOR THE YEARS 1890 TO 1910 INCLUSIVE.

To avoid crowding and needless repetition the minutes and their decimals only are given in this Table. Note therefore that 1° is to be added to each angular *datum* in the table for the total azimuth. Thus the azimuth for Lat. 40, year 1906, is 1° $33\frac{6}{10}'$.

LAT.	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	LAT.
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	°
4	16.9	16.6	16.2	15.9	15.6	15.3	15.0	14.7	14.4	14.0	13.7	13.4	13.1	12.8	12.5	12.1	11.8	11.5	11.2	10.9	10.6	4
8	17.4	17.1	16.8	16.5	16.2	15.9	15.6	15.3	15.0	14.6	14.3	14.0	13.7	13.3	13.0	12.7	12.4	12.1	11.8	11.5	11.1	8
12	18.4	18.1	17.8	17.5	17.1	16.8	16.5	16.2	15.9	15.5	15.2	14.9	14.6	14.2	13.9	13.6	13.3	12.9	12.6	12.3	12.0	12
16	19 8	19.5	19.1	18.8	18.5	18.2	17.9	17.5	17.2	16.9	16.6	16.2	15.9	15.5	15.2	14.9	14.6	14.2	13.9	13.6	13.3	16
20	21.6	21.3	20.9	20.6	20.2	19.9	19.6	19.3	19.0	18.6	18.3	17.9	17.6	17.3	17.0	16.6	16.3	15.9	15.6	15.3	14.9	20
24	23.9	23.6	23.2	22.9	22.5	22.2	21.9	21.5	21.2	20.9	20.6	20.2	19.9	19.5	19.2	18.8	18.5	18.1	17.8	17.5	17.1	24
26	25.3	25.0	24.6	24.3	23.9	23.6	23.2	22.9	22.5	22.2	21.8	21.5	21.1	20.8	20.5	20.1	19.8	19.4	19.1	18.7	18.4	26
28	26.8	26.5	26.2	25.8	25.4	25.1	24.7	24.4	24.0	23.7	23.3	23 0	22.6	22.2	21.9	21.6	21.3	20.9	20.5	20.1	19.8	28
30	28.5	28.2	27.8	27.5	27.1	26.8	26.1	26.0	25.7	25.3	24.9	24.6	24.2	23.9	23.5	23.1	22.8	22.4	22.1	21.7	21.3	30
32	30.4	30.1	29.7	29.3	29.0	28.6	28.2	27.8	27.5	27.1	25.7	26.4	26.0	25.6	25.3	24.9	24.5	24.1	23.8	23.4	23.1	32
34	32.5	32.1	31.8	31.4	31.0	30.6	30.3	29.9	29.5	29.1	28.7	28.4	28.0	27.6	27.2	26.9	26.5	26.1	25.7	25.3	25 0	34
36	34.8	34.4	34.0	33.6	33.2	32.9	32.5	32.1	31.7	31.3	30.9	30.5	30.1	29.8	29.4	29.0	28.6	28.2	27.9	27.5	27.1	36
38	37.3	36.9	36.5	36.1	35.7	35.3	34.9	34.5	34.1	33.7	33.3	33.0	32.6	32.2	31.8	31.4	31.0	30.6	30.2	29.8	29.4	38
40	40.1	39.7	39.3	38.9	38.5	38.1	37.7	37.3	36.8	36.4	36.0	35.6	35.2	34.8	34.4	34.0	33.6	33.2	32.8	32.4	32.0	40
42	43.2	42.8	42.4	42.0	41.5	41.1	40.7	40.3	39.8	39.4	39.0	38.6	38.2	37.7	37.3	36.9	36.5	36.0	35.6	35.2	34.8	42
44	46.6	46.2	45.8	45.3	44.9	44.4	44.0	43.6	43.1	42.7	42.3	41.8	41.4	41.0	40.5	40.1	39.7	39.2	38.8	38.4	37.9	44
46	50.5	50.0	49.5	49.0	48.6	48.2	47.7	47.3	46.8	46.4	45.9	45.5	45.0	44.6	44.2	43.7	43.2	42.7	42.3	41.9	41.4	46
48	54.6	54.2	53.7	53.2	52.8	52.3	51.9	51.4	50.9	50.4	49.9	49.5	49.0	48.6	48.1	47.7	47.2	46.7	46.3	45.8	45.3	48
50	59.3	58.8	58.4	57.9	57.4	56.9	56.4	55.9	55.4	54 9	54.5	54.0	53.5	53.0	52.5	52.0	51.5	51.0	50.6	50.1	49.6	50

TABLE III.

ROODS AND PERCHES IN DECIMAL PARTS OF AN ACRE.

One Acre = 4 Roods = 160 Perches = 4,840 Square Yards = 43,560 Square Feet.

Perches.	Roods.				Perches.	Roods.			
	0	1	2	3		0	1	2	3
0	.000	.250	.500	.750	21	.131	.381	.631	.881
1	.006	.256	.506	.756	22	.137	.387	.637	.887
2	.012	.262	.512	.762	23	.144	.394	.644	.894
3	.019	.269	.519	.769	24	.150	.400	.650	.900
4	.025	.275	.525	.775	25	.156	.406	.656	.906
5	.031	.281	.531	.781	26	.162	.412	.662	.912
6	.037	.287	.537	.787	27	.169	.419	.669	.919
7	.044	.294	.544	.794	28	.175	.425	.675	.925
8	.050	.300	.550	.800	29	.181	.431	.681	.931
9	.056	.306	.556	.806	30	.187	.437	.687	.937
10	.062	.312	.562	.812	31	.194	.444	.694	.944
11	.069	.319	.569	.819	32	.200	.450	.700	.950
12	.075	.325	.575	.825	33	.206	.456	.706	.956
13	.081	.331	.581	.831	34	.212	.462	.712	.962
14	.087	.337	.587	.837	35	.219	.469	.719	.969
15	.094	.344	.594	.844	36	.225	.475	.725	.975
16	.100	.350	.600	.850	37	.231	.481	.731	.981
17	.106	.356	.606	.856	38	.237	.487	.737	.987
18	.112	.362	.612	.862	39	.244	.494	.744	.994
19	.119	.369	.619	.869	40	.250	.500	.750	1.000
20	.125	.375	.625	.875					

TABLE IV.

DECIMALS OF AN ACRE IN ONE CHAIN LENGTH OF 100 FEET, AND OF VARIOUS WIDTHS.

Width in Rods.	Decimals of an Acre per 100 Feet.	Acres per Mile.	Width in Rods.	Decimals of an Acre per 100 Feet.	Acres per Mile.
½	.018939	1	5½	.208333	11
1	.037879	2	6	.227273	12
1½	.056818	3	6½	.246212	13
2	.075757	4	7	.265151	14
2½	.094697	5	7½	.284091	15
3	.113636	6	8	.303030	16
3½	.132576	7	8½	.321970	17
4	.151515	8	9	.340909	18
4½	.170454	9	9½	.359848	19
5	.189394	10	10	.378788	20

TABLE V.

ACRES, ROODS, AND PERCHES IN SQUARE FEET.

Acres.	Square Feet.	Roods.	Square Feet.	Perches.	Square Feet.
1	43560	1	10890	17	4628.25
2	87120	2	21780	18	4900.50
3	130680	3	32670	19	5172.75
4	174240	4	43560	20	5445.00
5	217800			21	5717.75
6	261360	Perches.	Square Feet.	22	5989.50
7	304920			23	6261.75
8	348480			24	6534.00
9	392040	1	272.25	25	6806.25
10	435600	2	544.50	26	7078.50
11	479160	3	816.75	27	7350.75
12	522720	4	1089.00	28	7623.00
13	566280	5	1361.25	29	7895.25
14	609840	6	1633.50	30	8167.50
15	653400	7	1905.75	31	8439.75
16	696960	8	2178.00	32	8712.00
17	740520	9	2450.25	33	8984.25
18	783080	10	2722.50	34	9256.50
19	827640	11	2994.75	35	9528.75
20	871200	12	3267.00	36	9801.00
21	916760	13	3539.25	37	10073.25
22	960320	14	3811.50	38	10345.50
		15	4083.75	39	10617.75
		16	4356.00	40	10890.00

TABLE VI.

CIRCULAR ARCS TO RADIUS OF 1.

DEGREES.		MINUTES.		SECONDS.	
°		′		″	
1	.01745329	1	.00029089	1	.00000485
2	.03490658	2	.00058178	2	.00000970
3	.05235988	3	.00087266	3	.00001454
4	.06981317	4	.00116355	4	.00001939
5	.08726646	5	.00145444	5	.00002424
6	.10471975	6	.00174533	6	.00002909
7	.12217305	7	.00203622	7	.00003394
8	.13962634	8	.00232711	8	.00003878
9	.15707963	9	.00261799	9	.00004363

TABLE VII.

FEET IN DECIMALS OF A MILE.

Feet.	Decimals of a Mile.
1	0.000189394
2	0.000378798
3	0.000568182
4	0.000757576
5	0.000946970
6	0.001136364
7	0.001325758
8	0.001515152
9	0.001704546

TABLE VIII.

INCHES REDUCED TO DECIMAL PARTS OF A FOOT.

In.	0	1	2	3	4	5	6	7	8	9	10	11	In.
0	.0000	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167	0
$\frac{1}{16}$	.0052	.0855	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219	$\frac{1}{16}$
$\frac{1}{8}$	.0104	.0938	.1771	.2604	.3438	.4271	.5104	.5938	.6771	.7604	.8438	.9271	$\frac{1}{8}$
$\frac{3}{16}$	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323	$\frac{3}{16}$
$\frac{1}{4}$	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375	$\frac{1}{4}$
$\frac{5}{16}$	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427	$\frac{5}{16}$
$\frac{3}{8}$	.0313	.1146	.1979	.2813	.3646	.4479	.5313	.6146	.6979	.7813	.8646	.9479	$\frac{3}{8}$
$\frac{7}{16}$	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531	$\frac{7}{16}$
$\frac{1}{2}$	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583	$\frac{1}{2}$
$\frac{9}{16}$	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635	$\frac{9}{16}$
$\frac{5}{8}$	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688	$\frac{5}{8}$
$\frac{11}{16}$	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740	$\frac{11}{16}$
$\frac{3}{4}$	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792	$\frac{3}{4}$
$\frac{13}{16}$	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844	$\frac{13}{16}$
$\frac{7}{8}$	.0729	.1563	.2396	.3229	.4063	.4896	.5729	.6563	.7396	.8229	.9063	.9896	$\frac{7}{8}$
$\frac{15}{16}$	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948	$\frac{15}{16}$

TABLE IX.

RADII AND THEIR LOGARITHMS, MIDDLE ORDINATES, AND DEFLECTION DISTANCES.

NOTE.—This table applies to chords of 100-*feet* units. To use it for chords of 20-*metre* units, divide the degree of the proposed metric curve by 2 and find the quotient in the first column of the table; or multiply any tabular degree of curve by 2 for the degree of the proposed metric curve. Then *one-tenth* of the radius opposite the tabular degree thus found or assumed will give very nearly the true radius in metres of the proposed metric curve, and *four-tenths* of the corresponding figures in the last three columns will give very nearly the values of those functions in metric measure. Thus, if a 3° metric curve be proposed, we take one-tenth of the radius opposite the tabular degree 1° 30′, or 382 metres, and find the values of the functions in the last three columns to be .1308, 1.048, and .524. Resulting errors may be neglected except in work of extraordinary accuracy.

Degree of Curve.		Radius.	Logarithm of Radius.	Arithmetical Complement.	Middle Ordinate, Chord 100 Feet.	Deflection Distance.	Tangential Distance.
°	′						
0	5	68754.9	4.837304	5.162696	.018	.145	.073
	10	34377.5	4.536274	5.463726	.036	.291	.145
	15	22918.3	4.360182	5.639818	.055	.436	.218
	20	17188.8	4.235246	5.764754	.073	.582	.291
	25	13751.0	4.138335	5.861665	.091	.727	.364
	30	11459.2	4.059154	5.940846	.109	.873	.436
	35	9822.2	3.992209	6.007791	.127	1.02	.509
	40	8594.4	3.934215	6.065785	.145	1.16	.582
	45	7639.5	3.883066	6.116934	.164	1.31	.654
	50	6875.5	3.837304	6.162696	.182	1.45	.727
	55	6250.5	3.795914	6.204086	.200	1.60	.800
1	0	5729.6	3.758128	6.241872	.218	1.75	.873
	5	5288.9	3.723365	6.276635	.236	1.89	.945
	10	4911.1	3.691179	6.308821	.255	2.04	1.02
	15	4583.7	3.661216	6.338784	.273	2.18	1.09
	20	4297.3	3.633195	6.366805	.291	2.33	1.16
	25	4044.5	3.606864	6.393136	.309	2.47	1.24
	30	3819.8	3.582041	6.417959	.327	2.62	1.31
	35	3618.8	3.558565	6.441435	.345	2.76	1.38
	40	3437.9	3.536293	6.463707	.364	2.91	1.45
	45	3274.2	3.515106	6.484894	.382	3.05	1.53
	50	3125.4	3.494906	6.505094	.400	3.20	1.60
	55	2989.5	3.475599	6.524401	.418	3.34	1.67
2	0	2864.9	3.457114	6.542886	.436	3.49	1.74
	5	2750.3	3.439380	6.560620	.455	3.64	1.82
	10	2644.6	3.422359	6.577641	.473	3.78	1.89
	15	2546.6	3.405961	6.594039	.491	3.93	1.96
	20	2455.7	3.390175	6.609825	.509	4.07	2.04
	25	2371.0	3.374932	6.625068	.527	4.22	2.11
	30	2292.0	3.360215	6.639785	.545	4.36	2.18
	35	2218.1	3.345982	6.654018	.564	4.51	2.25
	40	2148.8	3.332196	6.667804	.582	4.65	2.33
	45	2083.7	3.318835	6.681165	.600	4.80	2.40
	50	2022.4	3.305867	6.694133	.618	4.94	2.47
	55	1964.6	3.293274	6.706726	.636	5.09	2.54
3	0	1910.1	3.281056	6.718944	.655	5.23	2.62
	5	1858.5	3.269163	6.730837	.673	5.38	2.69
	10	1809.6	3.257584	6.742416	.691	5.53	2.76
	15	1763.2	3.246301	6.753699	.709	5.67	2.84
	20	1719.1	3.235301	6.764699	.727	5.82	2.91
	25	1677.2	3.224585	6.775415	.745	5.96	2.98
	30	1637.3	3.214129	6.785871	.764	6.11	3.05
	35	1599.2	3.203902	6.796098	.782	6.25	3.13
	40	1562.9	3.193931	6.806069	.800	6.40	3.20
	45	1528.2	3.184180	6.815819	.818	6.54	3.27
	50	1495.0	3.174641	6.825359	.836	6.69	3.34
	55	1463.2	3.165303	6.834607	.855	6.83	3.42
4	0	1432.7	3.156155	6.843845	.873	6.98	3.49
	5	1403.5	3.147212	6.852788	.891	7.12	3.56
	10	1375.4	3.138429	6.861571	.909	7.27	3.63
	15	1348.4	3.129819	6.870181	.927	7.42	3.71
	20	1322.5	3.121395	6.878605	.945	7.56	3.78
	25	1297.6	3.113141	6.886859	.964	7.71	3.85
	30	1273.6	3.105033	6.894967	.982	7.85	3.93
	35	1250.4	3.097048	6.902952	1.00	8.00	4.00
	40	1228.1	3.089233	6.910767	1.02	8.14	4.07

Degree of Curve.	Radius.	Logarithm of Radius.	Arithmetical Complement.	Middle Ordinate, Chord 100 Feet.	Deflection Distance.	Tangential Distance.
° ′						
4 45	1206.6	3.081563	6.918437	1.04	8.29	4.14
50	1185.8	3.074011	6.925989	1.05	8.43	4.22
55	1165.7	3.066587	6.933413	1.07	8.58	4.29
5 0	1146.3	3.059299	6.940701	1.09	8.72	4.36
5	1127.5	3.052117	6.947883	1.11	8.87	4.43
10	1109.3	3.045050	6.954950	1.13	9.01	4.51
15	1091.7	3.038103	6.961897	1.15	9.16	4.58
20	1074.7	3.031287	6.968713	1.16	9.30	4.65
25	1058.2	3.024568	6.975432	1.18	9.45	4.72
30	1042.1	3.017910	6.982090	1.20	9.60	4.80
35	1026.6	5.011401	6.988599	1.22	9.74	4.87
40	1011.5	3.004967	6.995033	1.24	9.89	4.94
45	996.9	2.998652	7.001348	1.25	10.0	5.02
50	982.6	2.992377	7.007623	1.27	10.2	5.09
55	968.8	2.986234	7.013766	1.29	10.3	5.16
6 0	955.4	2.980185	7.019815	1.31	10.5	5.23
5	942.3	2.974189	7.025811	1.33	10.6	5.31
10	929.6	2.968296	7.031704	1.35	10.8	5.38
15	917.2	2.962464	7.037536	1.36	10.9	5.45
20	905.1	2.956697	7.043303	1.38	11.0	5.52
25	893.4	2.951046	7.048954	1.40	11.2	5.60
30	882.0	2.945469	7.054531	1.42	11.3	5.67
35	870.8	2.939918	7.060082	1.44	11.5	5.74
40	859.9	2.934448	7.065552	1.45	11.6	5.81
45	849.3	2.929061	7.070939	1.47	11.8	5.89
50	839.0	2.923762	7.076238	1.49	11.9	5.96
55	828.9	2.918502	7.082498	1.51	12.1	6.03
7 0	819.0	2.913284	7.086716	1.53	12.2	6.10
5	809.4	2.908163	7.091837	1.55	12.3	6.18
10	800.0	2.903090	7.096910	1.56	12.5	6.25
15	790.8	2.898067	7.101933	1.58	12.6	6.32
20	781.8	2.893096	7.106904	1.60	12.8	6.39
25	773.1	2.888236	7.111764	1.62	12.9	6.47
30	764.5	2.883377	7.116623	1.64	13.1	6.54
35	756.1	2.878579	7.121421	1.65	13.2	6.61
40	747.9	2.873844	7.126156	1.67	13.4	6.68
45	739.9	2.869173	7.130827	1.69	13.5	6.76
50	732.0	2.864511	7.135489	1.71	13.7	6.83
55	724.3	2.859918	7.140082	1.73	13.8	6.90
8 0	716.8	2.855398	7.144602	1.75	14.0	6.98
5	709.4	2.850891	7.149109	1.76	14.1	7.05
10	702.2	2.846461	7.153539	1.78	14.2	7.12
15	695.1	2.842047	7.157953	1.80	14.4	7.19
20	688.2	2.837715	7.162285	1.82	14.5	7.27
25	681.3	2.833338	7.166662	1.84	14.7	7.34
30	674.7	2.829111	7.170889	1.85	14.8	7.41
35	668.1	2.824841	7.175159	1.87	15.0	7.48
40	661.7	2.820661	7.179339	1.89	15.1	7.56
45	655.4	2.816506	7.183494	1.91	15.3	7.63
50	649.3	2.812445	7.187555	1.93	15.4	7.70
55	643.2	2.808346	7.181654	1.95	15.5	7.77
9 0	637.3	2.804344	7.195656	1.96	15.7	7.85
5	631.4	2.800305	7.199695	1.98	15.8	7.92
10	625.7	2.796366	7.203634	2.00	16.0	7.99
15	620.1	2.792462	7.207538	2.02	16.1	8.06

Degree of Curve.		Radius.	Logarithm of Radius.	Arithmetical Complement.	Middle Ordinate, Chord 100 Feet.	Deflection Distance.	Tangential Distance.
°	′						
9	20	614.6	2.788593	7.211407	2.04	16.3	8.14
	25	609.1	2.784689	7.215311	2.06	16.4	8.21
	30	603.8	2.780893	7.219107	2.07	16.6	8.28
	35	598.6	2.777137	7.222863	2.09	16.7	8.35
	40	593.4	2.773348	7.226652	2.11	16.8	8.43
	45	588.4	2.769673	7.230327	2.13	17.0	8.50
	50	583.4	2.765966	7.234134	2.15	17.1	8.57
	55	578.5	2.762303	7.237697	2.16	17.3	8.64
10	0	573.7	2.758685	7.241315	2.18	17.4	8.72
	10	564.3	2.751510	7.248490	2.22	17.7	8.86
	20	555.2	2.744449	7.255551	2.26	18.0	9.00
	30	546.4	2.737511	7.262489	2.29	18.3	9.15
	40	537.9	2.730702	7.269298	2.33	18.6	9.30
	50	529.7	2.724030	7.275970	2.36	18.9	9.44
11	0	521.7	2.717421	7.282579	2.40	19.2	9.58
	10	513.9	2.710879	7.289121	2.44	19.5	9.73
	20	506.4	2.704494	7.295506	2.47	19.7	9.87
	30	499.1	2.698188	7.301812	2.51	20.0	10.0
	40	492.0	2.691965	7.308035	2.55	20.3	10.2
	50	485.1	2.685831	7.314169	2.58	20.6	10.3
12	0	478.3	2.679700	7.320300	2.62	20.9	10.4
	10	471.8	2.673758	7.326242	2.66	21.2	10.6
	20	465.5	2.667920	7.332080	2.69	21.5	10.7
	30	459.3	2.662096	7.337904	2.73	21.8	10.9
	40	453.3	2.656386	7.343614	2.77	22.1	11.0
	50	447.4	2.650696	7.349304	2.80	22.4	11.2
13	0	441.7	2.645127	7.354873	2.84	22.6	11.3
	10	436.1	2.639586	7.360414	2.88	22.9	11.5
	20	430.7	2.634175	7.365825	2.91	23.2	11.6
	30	425.4	2.628797	7.371203	2.95	23.5	11.7
	40	420.2	2.623456	7.376544	2.98	23.8	11.9
	50	415.2	2.618257	7.381743	3.02	24.1	12.0
14	0	410.3	2.613102	7.386898	3.06	24.4	12.2
	10	405.5	2.607991	7.392009	3.09	24.7	12.3
	20	400.8	2.602928	7.397072	3.13	25.0	12.5
	30	396.2	2.597914	7.402086	3.17	25.2	12.6
	40	391.7	2.592954	7.407046	3.20	25.5	12.8
	50	387.3	2.588047	7.411953	3.24	25.8	12.9
15	0	383.1	2.583312	7.416688	3.28	26.1	13.0
	10	378.9	2.578525	7.421475	3.31	26.4	13.2
	20	374.8	2.573800	7.426200	3.35	26.7	13.3
	30	370.8	2.569140	7.430860	3.39	27.0	13.5
	40	366.9	2.564548	7.435452	3.42	27.3	13.6
	50	363.0	2.559907	7.440093	3.46	27.5	13.8
16	0	359.3	2.555457	7.444543	3.50	27.8	13.9
	10	355.6	2.550962	7.449038	3.53	28.1	14.1
	20	352.0	2.546543	7.453457	3.57	28.4	14.2
	30	348.4	2.542078	7.457922	3.61	28.7	14.3
	40	345.0	2.537819	7.462181	3.64	29.0	14.5
	50	341.6	2.533518	7.466482	3.68	29.3	14.6
17	0	338.3	2.529302	7.470698	3.72	29.6	14.8
	10	335.0	2.525045	7.474955	3.75	29.9	14.9

Degree of Curve.		Radius.	Logarithm of Radius.	Arithmetical Complement.	Middle Ordinate, Chord 100 Feet.	Deflection Distance.	Tangential Distance.
°	′						
17	20	331.8	2.520876	7.479124	3.79	30.1	15.1
	30	328.7	2.516800	7.483200	3.82	30.4	15.2
	40	325.6	2.512684	7.487316	3.86	30.7	15.4
	50	322.6	2.508664	7.491336	3.90	31.0	15.5
18	0	319.6	2.504607	7.495393	3.93	31.3	15.6
	10	316.7	2.500648	7.499352	3.97	31.6	15.8
	20	313.9	2.496791	7.503209	4.01	31.9	15.9
	30	311.1	2.492900	7.507100	4.04	32.1	16.1
	40	308.3	2.488974	7.511026	4.08	32.4	16.2
	50	305.6	2.485153	7.514847	4.12	32.7	16.4
19	0	302.9	2.481299	7.518701	4.15	33.0	16.5
	10	300.3	2.477555	7.522445	4.19	33.3	16.6
	20	297.8	2.473925	7.526075	4.23	33.6	16.8
	30	295.2	2.470116	7.529884	4.26	33.9	16.9
	40	292.8	2.466571	7.533429	4.30	34.2	17.1
	50	290.3	2.462847	7.537153	4.34	34.4	17.2
20	0	287.9	2.459242	7.540758	4.37	34.7	17.4

TABLE X.—(See p. 160.)

FOR USE WITH A 20-METRE CHAIN.

Engineers accustomed to thinking their *degree of curvature* with reference to the 100-ft. chain may find it convenient to remember that the degree of curvature, if a 20-metre chain be used, is approximately *two-thirds* of the foregoing. Thus a 3° metric curve would be about equivalent to a 4½° curve laid out with the 100-ft. chain.

A 20-metre chain = 65.618 feet; a 100-ft. chain = 1.524 chains of 20 metres each, one foot being equal to 0.3048 of a metre, and a metre equal to 3.2809 feet.

If a metric curve is to be retraced with a 100-ft. chain, the exact degree of curvature should be ascertained with reference to the radius in feet, as set forth in Art. XVIII.

It is convenient to mark stakes with the even numbers, 2, 4, 6, etc , when using the 20-metre chain, distance being thus recorded in tens of metres.

Degree of Curve.		Radius in Metres.	Logarithm of Radius.	Arithmetical Complement.	Mid. Ord. Chord 20 Metres.	Deflection Distance.	Tangential Distance.
°	′						
	10	6875.50	3.837304	6.162696	.0076	.0582	.0291
	20	3437.75	3.536274	6.463726	.0144	.1164	.0582
	30	2291.84	3.360184	6.639816	.0218	.1745	.0873
	40	1718.88	3.235246	6.764754	.0290	.2327	.1164
	50	1375.11	3.138338	6.861663	.0363	.2909	.1454
1	0	1145.93	3.059158	6.940842	.0437	.3491	.1745
	10	982.23	2.992213	7.007787	.0509	.4072	.2036
	20	859.46	2.934226	7.065774	.0582	.4654	.2327
	30	763.97	2.883076	7.116924	.0655	.5236	.2618
	40	687.57	2.837317	7.162683	.0727	.5818	.2909
	50	625.07	2.795929	7.204071	.0800	.6399	.3200
2	0	572.99	2.758147	7.241853	.0873	.6981	.3490
	10	528.92	2.723390	7.276610	.0945	.7563	.3781
	20	491.14	2.691205	7.308795	.1018	.8144	.4072
	30	458.40	2.661245	7.338755	.1091	.8726	.4363
	40	429.76	2.633226	7.366774	.1164	.9308	.4654
	50	404.48	2.606897	7.393103	.1237	.9889	.4945
3	0	382.02	2.582086	7.417914	.1309	1.047	.5235
	10	361.91	2.558601	7.440399	.1382	1.105	.5526
	20	343.82	2.536331	7.463669	.1454	1.163	.5817
	30	327.46	2.515158	7.484842	.1527	1.222	.6108
	40	312.58	2.494961	7.505039	.1600	1.280	.6398
	50	298.99	2.475657	7.524343	.1673	1.338	.6689
4	0	286.54	2.457185	7.542815	.1746	1.396	.6980
	10	275.08	2.439459	7.560541	.1818	1.454	.7271
	20	264.51	2.422442	7.577558	.1891	1.512	.7561
	30	254.71	2.406046	7.593954	.1964	1.570	.7852
	40	245.62	2.390264	7.609736	.2036	1.629	.8143
	50	237.16	2.375041	7.624959	.2109	1.687	.8433
5	0	229.26	2.360328	7.639672	.2182	1.745	.8726
	20	214.94	2.332317	7.667683	.2328	1.861	.9308
	40	202.30	2.305996	7.694004	.2473	1.977	.9889
6	0	191.07	2.280193	7.719307	.2619	2.093	1.047
	20	181.03	2.257751	7.742249	.2764	2.210	1.105
	40	171.98	2.235478	7.764522	.2910	2.326	1.163
7	0	163.80	2.214314	7.785686	.3055	2.442	1.222
	20	156.37	2.194153	7.805847	.3201	2.558	1.280
	40	149.58	2.174874	7.825126	.3347	2.674	1.338
8	0	143.36	2.156428	7.843572	.3492	2.790	1.396
	20	137.63	2.138713	7.861287	.3638	2.906	1.454
	40	132.35	2.121724	7.878276	.3783	3.022	1.512
9	0	127.45	2.105310	7.894660	.3929	3.138	1.570
	20	122.91	2.089587	7.910413	.4075	3.254	1.629
	40	118.68	2.074378	7.925622	.4220	3.370	1.687
10	0	114.74	2.059715	7.940285	.4366	3.486	1.745
	30	109.29	2.038580	7.961420	.4585	3.660	1.832
11	0	104.33	2.018409	7.981591	.4803	3.834	1.919
	30	99.81	1.999174	8.000826	.5022	4.008	2.006
12	0	95.67	1.980776	8.019224	.5241	4.181	2.093
	30	91.86	1.963126	8.036874	.5460	4.355	2.181
13	0	83.34	1.946157	8.053843	.5679	4.528	2.268
	30	85.08	1.929828	8.070172	.5897	4.701	2.355
14	0	82.06	1.914132	8.085868	.6117	4.875	2.442

TABLE XI.

SQUARES, CUBES, ETC., OF NUMBERS

FROM 1 TO 1042.

Note.—If N be taken to represent any number in any column of this table, then the algebraic significance of the remaining numbers, on the same line, in terms of N, will be as given in the following synopsis:

N	N^2	N^3	$\sqrt{N}$	$\sqrt[3]{N}$	$\frac{1}{N}$
$\sqrt{N}$	N	$\sqrt{N^3}$	$\sqrt[4]{N}$	$\sqrt[6]{N}$	$\frac{1}{\sqrt{N}}$
$\sqrt[3]{N}$	$\sqrt[3]{N^2}$	N	$\sqrt[6]{N}$	$\sqrt[9]{N}$	$\frac{1}{\sqrt[3]{N}}$
N^2	N^4	N^6	N	$\sqrt[3]{N^2}$	$\frac{1}{N^2}$
N^3	N^6	N^9	$\sqrt{N^3}$	N	$\frac{1}{N^3}$
$\frac{1}{N}$	$\frac{1}{N^2}$	$\frac{1}{N^3}$	$\sqrt{\frac{1}{N}}$	$\sqrt[3]{\frac{1}{N}}$	N

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
237	56169	13312053	15·3948043	6·1884628	·004219409
238	56644	13481272	15·4272486	6·1971544	·004201681
239	57121	13651919	15·4596248	6·2058218	·004184100
240	57600	13824000	15·4919334	6·2144650	·004166667
241	58081	13997521	15·5241747	6·2230843	·004149378
242	58564	14172488	15·5563492	6·2316797	·004132231
243	59049	14348907	15·5884573	6·2402515	·004115226
244	59536	14526784	15·6204994	6·2487998	·004098361
245	60025	14706125	15·6524758	6·2573248	·004081633
246	60516	14886936	15·6843871	6·2658266	·004065041
247	61009	15069223	15·7162336	6·2743054	·004048583
248	61504	15252992	15·7480157	6·2827613	·004032258
249	62001	15438249	15·7797338	6·2911946	·004016064
250	62500	15625000	15·8113883	6·2996053	·004000000
251	63001	15813251	15·8429795	6·3079935	·003984064
252	63504	16003008	15·8745079	6·3163596	·003968254
253	64009	16194277	15·9059737	6·3247035	·003952569
254	64516	16387064	15·9373775	6·3330256	·003937008
255	65025	16581375	15·9687194	6·3413257	·003921569
256	65536	16777216	16·0000000	6·3496042	·003906250
257	66049	16974593	16·0312195	6·3578611	·003891051
258	66564	17173512	16·0623784	6·3660968	·003875969
259	67081	17373979	16·0934769	6·3743111	·003861004
260	67600	17576000	16·1245155	6·3825043	·003846154
261	68121	17779581	16·1554944	6·3906765	·003831418
262	68644	17984728	16·1864141	6·3988279	·003816794
263	69169	18191447	16·2172747	6·4069585	·003802281
264	69696	18399744	16·2480768	6·4150687	·003787879
265	70225	18609625	16·2788206	6·4231583	·003773585
266	70756	18821096	16·3095064	6·4312276	·003759398
267	71289	19034163	16·3401346	6·4392767	·003745318
268	71824	19248832	16·3707055	6·4473057	·003731343
269	72361	19465109	16·4012195	6·4553148	·003717472
270	72900	19683000	16·4316767	6·4633041	·003703704
271	73441	19902511	16·4620776	6·4712736	·003690037
272	73984	20123648	16·4924225	6·4792236	·003676471
273	74529	20346417	16·5227116	6·4871541	·003663004
274	75076	20570824	16·5529454	6·4950653	·003649635
275	75625	20796875	16·5831240	6·5029572	·003636364
276	76176	21024576	16·6132477	6·5108300	·003623188
277	76729	21253933	16·6433170	6·5186839	·003610108
278	77284	21484952	16·6733320	6·5265189	·003597122
279	77841	21717639	16·7032931	6·5343351	·003584229
280	78400	21952000	16·7332005	6·5421326	·003571429
281	78961	22188041	16·7630546	6·5499116	·003558719
282	79524	22425768	16·7928556	6·5576722	·003546099
283	80089	22665187	16·8226038	6·5654144	·003533569
284	80656	22906304	16·8522995	6·5731385	·003522127
285	81225	23149125	16·8819430	6·5808443	·003508772
286	81796	23393656	16·9115345	6·5885323	·003496503
287	82369	23639903	16·9410743	6·5962023	·003484321
288	82944	23887872	16·9705627	6·6038545	·003472222
289	83521	24137569	17·0000000	6·6114890	·003460208
290	84100	24389000	17·0293864	6·6191060	·003448276
291	84681	24642171	17·0587221	6·6267054	·003436426
292	85264	24897088	17·0880075	6·6342874	·003424658
293	85849	25153757	17·1172428	6·6418522	·003412969
294	86436	25412184	17·1464282	6·6493998	·003401361
295	87025	25672375	17·1755640	6·6569302	·003389831
296	87616	25934336	17·2046505	6·6644437	·003378378
297	88209	26198073	17·2336879	6·6719403	·003367003
298	88804	26463592	17·2626765	6·6794200	·003355705

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
299	89401	26730899	17·2916165	6·6868831	·003344482
300	90000	27000000	17·3205081	6·6943295	·003333333
301	90601	27270901	17·3493516	6·7017593	·003322259
302	91204	27543608	17·3781472	6·7091729	·003311258
303	91809	27818127	17·4068952	6·7165700	·003301330
304	92416	28094464	17·4355958	6·7239508	·003289474
305	93025	28372625	17·4642492	6·7313155	·003278689
306	93636	28652616	17·4928557	6·7386641	·003267974
307	94249	28934443	17·5214155	6·7459967	·003257329
308	94864	29218112	17·5499288	6·7533134	·003246753
309	95481	29503629	17·5783958	6·7606143	·003236246
310	96100	29791000	17·6068169	6·7678995	·003225806
311	96721	30080231	17·6351921	6·7751690	·003215434
312	97344	30371328	17·6635217	6·7824229	·003205128
313	97969	30664297	17·6918060	6·7896613	·003194888
314	98596	30959144	17·7200451	6·7968844	·003184713
315	99225	31255875	17·7482393	6·8040921	·003174603
316	99856	31554496	17·7763888	6·8112847	·003164557
317	100489	31855013	17·8044938	6·8184620	·003154574
318	101124	32157432	17·8325545	6·8256242	·003144654
319	101761	32461759	17·8605711	6·8327714	·003134796
320	102400	32768000	17·8885438	6·8399037	·003125000
321	103041	33076161	17·9164729	6·8470213	·003115265
322	103684	33386248	17·9443584	6·8541240	·003105590
323	104329	33698267	17·9722008	6·8612120	·003095975
324	104976	34012224	18·0000000	6·8682855	·003086420
325	105625	34328125	18·0277564	6·8753443	·003076923
326	106276	34645976	18·0554701	6·8823888	·003067485
327	106929	34965783	18·0831413	6·8894188	·003058104
328	107584	35287552	18·1107703	6·8964345	·003048780
329	108241	35611289	18·1383571	6·9034359	·003039514
330	108900	35937000	18·1659021	6·9104232	·003030303
331	109561	36264691	18·1934054	6·9173964	·003021148
332	110224	36594368	18·2208672	6·9243556	·003012048
333	110889	36926037	18·2482876	6·9313008	·003003003
334	111556	37259704	18·2756669	6·9382321	·002994012
335	112225	37595375	18·3030052	6·9451496	·002985075
336	112896	37933056	18·3303028	6·9520533	·002976190
337	113569	38272753	18·3575598	6·9589434	·002967359
338	114244	38614472	18·3847763	6·9658198	·002958580
339	114921	38958219	18·4119526	6·9726826	·002949853
340	115600	39304000	18·4390889	6·9795321	·002941176
341	116281	39651821	18·4661853	6·9863681	·002932551
342	116964	40001688	18·4932420	6·9931906	·002923977
343	117649	40353607	18·5202592	7·0000000	·002915452
344	118336	40707584	18·5472370	7·0067962	·002906977
345	119025	41063625	18·5741756	7·0135791	·002898551
346	119716	41421736	18·6010752	7·0203490	·002890173
347	120409	41781923	18·6279360	7·0271058	·002881844
348	121104	42144192	18·6547581	7·0338497	·002873563
349	121801	42508549	18·6815417	7·0405806	·002865330
350	122500	42875000	18·7082869	7·0472987	·002857143
351	123201	43243551	18·7349940	7·0540041	·002849003
352	123904	43614208	18·7616630	7·0606967	·002840909
353	124609	43986977	18·7882942	7·0673767	·002832861
354	125316	44361864	18·8148877	7·0740440	·002824859
355	126025	44738875	18·8414437	7·0806988	·002816901
356	126736	45118016	18·8679623	7·0873411	·002808989
357	127449	45499293	18·8944436	7·0939709	·002801120
358	128164	45882712	18·9208879	7·1005885	·002793296
359	128881	46268279	18·9472953	7·1071937	·002785515
360	129600	46656000	18·9736660	7·1137866	·002777778

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
361	130321	47045881	19·0000000	7·1203674	·002770083
362	131044	47437928	19·0262976	7·1269360	·002762431
363	131769	47832147	19·0525589	7·1334925	·002754821
364	132496	48228544	19·0787840	7·1400370	·002747253
365	133225	48627125	19·1049732	7·1465695	·002739726
366	133956	49027896	19·1311265	7·1530901	·002732240
367	134689	49430863	19·1572441	7·1595988	·002724796
368	135424	49836032	19·1833261	7·1660957	·002717391
369	136161	50243409	19·2093727	7·1725809	·002710027
370	136900	50653000	19·2353841	7·1790544	·002702703
371	137641	51064811	19·2613603	7·1855162	·002695418
372	138384	51478848	19·2873015	7·1919663	·002688172
373	139129	51895117	19·3132079	7·1984050	·002680965
374	139876	52313624	19·3390796	7·2048322	·002673797
375	140625	52734375	19·3649167	7·2112479	·002666667
376	141376	53157376	19·3907194	7·2176522	·002659574
377	142129	53582633	19·4164878	7·2240450	·002652520
378	142884	54010152	19·4422221	7·2304268	·002645503
379	143641	54439939	19·4679223	7·2367972	·002638521
380	144400	54872000	19·4935887	7·2431565	·002631579
381	145161	55306341	19·5192213	7·2495045	·002624672
382	145924	55742968	19·5448203	7·2558415	·002617801
383	146689	56181887	19·5703858	7·2621675	·002610966
384	147456	56623104	19·5959179	7·2684824	·002604167
385	148225	57066625	19·6214169	7·2747864	·002597403
386	148996	57512456	19·6468827	7·2810794	·002590674
387	149769	57960603	19·6723156	7·2873617	·002583979
388	150544	58411072	19·6977156	7·2936330	·002577320
389	151321	58863869	19·7230829	7·2998936	·002570694
390	152100	59319000	19·7484177	7·3061436	·002564103
391	152881	59776471	19·7737199	7·3123828	·002557545
392	153664	60236288	19·7989899	7·3186114	·002551020
393	154449	60698457	19·8242276	7·3248295	·002544529
394	155236	61162984	19·8494332	7·3310369	·002538071
395	156025	61629875	19·8746069	7·3372339	·002531646
396	156816	62099136	19·8997487	7·3434205	·002525253
397	157609	62570773	19·9248588	7·3495966	·002518892
398	158404	63044792	19·9499373	7·3557624	·002512563
399	159201	63521199	19·9749844	7·3619178	·002506266
400	160000	64000000	20·0000000	7·3680630	·002500000
401	160801	64481201	20·0249844	7·3741979	·002493766
402	161604	64964808	20·0499377	7·3803227	·002487562
403	162409	65450827	20·0748599	7·3864373	·002481390
404	163216	65939264	20·0997512	7·3925418	·002475248
405	164025	66430125	20·1246118	7·3986363	·002469136
406	164836	66923416	20·1494417	7·4047206	·002463054
407	165649	67419143	20·1742410	7·4107950	·002457002
408	166464	67917312	20·1990099	7·4168595	·002450980
409	167281	68417929	20·2237484	7·4229142	·002444988
410	168100	68921000	20·2484567	7·4289589	·002439024
411	168921	69426531	20·2731349	7·4349938	·002433090
412	169744	69934528	20·2977831	7·4410189	·002427184
413	170569	70444997	20·3224014	7·4470342	·002421308
414	171396	70957944	20·3469899	7·4530399	·002415459
415	172225	71473375	20·3715488	7·4590359	·002409639
416	173056	71991296	20·3960781	7·4650223	·002403846
417	173889	72511713	20·4205779	7·4709991	·002398082
418	174724	73034632	20·4450483	7·4769664	·002392344
419	175561	73560059	20·4694895	7·4829242	·002386635
420	176400	74088000	20·4939015	7·4888724	·002380952
421	177241	74618461	20·5182845	7·4948113	·002375297
422	178084	75151448	20·5426386	7·5007406	·002369668

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
423	178929	75686967	20·5669638	7·5066607	·002364066
424	179776	76225024	20·5912603	7·5125715	·002358491
425	180625	76765625	20·6155281	7·5184730	002352941
426	181476	77308776	20·6397674	7·5243652	·002347418
427	182329	77854483	20·6639783	7·5302482	·002341920
428	183184	78402752	20·6881609	7·5361221	·002336449
429	184041	78953589	20·7123152	7·5419867	002331002
430	184900	79507000	20·7364414	7·5478423	·002325581
431	185761	80062991	20·7605395	7·5536888	002320186
432	186624	80621568	20·7846097	7·5595263	002314815
433	187489	81182737	20·8086520	7·5653548	·002309469
434	188356	81746504	20·8326667	7·5711743	·002304147
435	189225	82312875	20·8566536	7·5769849	002298851
436	190096	82881856	20·8806130	7·5827865	·002293578
437	190969	83453453	20·9045450	7·5885793	·002288330
438	191844	84027672	20·9284495	7·5943633	·002283105
439	192721	84604519	20·9523268	7·6001385	·002277904
440	193600	85184000	20·9761770	7·6059049	·002272727
441	194481	85766121	21·0000000	7·6116626	·002267574
442	195364	86350888	21·0237960	7·6174116	·002262443
443	196249	86938307	21·0475652	7·6231519	·002257336
444	197136	87528384	21·0713075	7·6288837	·002252252
445	198025	88121125	21·0950231	7·6346067	·002247191
446	198916	88716536	21·1187121	7·6403213	002242152
447	199809	89314623	21·1423745	7·6460272	·002237136
448	200704	89915392	21·1660105	7·6517247	·002232143
449	201601	90518849	21·1896201	7·6574138	002227171
450	202500	91125000	21·2132034	7·6630943	·002222222
451	203401	91733851	21·2367606	7·6687665	·002217295
452	204304	92345408	21·2602916	7·6744303	002212389
453	205209	92959677	21·2837967	7·6800857	·002207506
454	206116	93576664	21·3072758	7·6857328	·002202643
455	207025	94196375	21·3307290	7·6913717	·002197802
456	207936	94818816	21·3541565	7·6970023	·002192982
457	208849	95443993	21·3775583	7·7026246	·002188184
458	209764	96071912	21·4009346	7·7082388	·002183406
459	210681	96702579	21·4242853	7·7138448	·002178649
460	211600	97336000	21·4476106	7·7194426	·002173913
461	212521	97972181	21·4709106	7·7250325	·002169197
462	213444	98611128	21·4941853	7·7306141	·002164502
463	214369	99252847	21·5174348	7·7361877	·002159827
464	215296	99897344	21·5406592	7·7417532	·002155172
465	216225	100544625	21·5638587	7·7473109	·002150538
466	217156	101194696	21·5870331	7·7528606	·002145923
467	218089	101847563	21·6101828	7·7584023	·002141328
468	219024	102503232	21·6333077	7·7639361	002136752
469	219961	103161709	21·6564078	7·7694620	002132196
470	220900	103823000	21·6794834	7·7749801	·002127660
471	221841	104487111	21·7025344	7·7804904	·002123142
472	222784	105154048	21·7255610	7·7859928	002118644
473	223729	105823817	21·7485632	7·7914875	002114165
474	224676	106496424	21·7715411	7·7969745	002109705
475	225625	107171875	21·7944947	7·8024538	002105263
476	226576	107850176	21·8174242	7·8079254	·002100840
477	227529	108531333	21·8403297	7·8133892	002096436
478	228484	109215352	21·8632111	7·8188456	·002092050
479	229441	109902239	21·8860686	7·8242942	002087683
480	230400	110592000	21·9089023	7·8297353	·002083333
481	231361	111284641	21·9317122	7·8351688	·002079002
482	232324	111980168	21·9544984	7·8405949	002074689
483	233289	112678587	21·9772610	7·8460134	·002070393
484	234256	113379904	22·0000000	7·8514244	·002066116

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
485	235225	114084125	22·0227155	7·8568281	·002061856
486	236196	114791256	22·0454077	7·8622242	·002057613
487	237169	115501303	22·0680765	7·8676130	·002053388
488	238144	116214272	22·0907220	7·8729944	·002049180
489	239121	116930169	22·1133444	7·8783684	·002044990
490	240100	117649000	22·1359436	7·8837352	·002040816
491	241081	118370771	22·1585198	7·8890946	·002036660
492	242064	119095488	22·1810730	7·8944468	·002032520
493	243049	119823157	22·2036033	7·8997917	·002028398
494	244036	120553784	22·2261108	7·9051294	·002024291
495	245025	121287375	22·2485955	7·9104599	·002020202
496	246016	122023936	22·2710575	7·9157832	·002016129
497	247009	122763473	22·2934968	7·9210994	·002012072
498	248004	123505992	22·3159136	7·9264085	·002008032
499	249001	124251499	22·3383079	7·9317104	·002004008
500	250000	125000000	22·3606798	7·9370053	·002000000
501	251001	125751501	22·3830293	7·9422931	·001996008
502	252004	126506008	22·4053565	7·9475739	·001992032
503	253009	127263527	22·4276615	7·9528477	·001988072
504	254016	128024064	22·4499443	7·9581144	·001984127
505	255025	128787625	22·4722051	7·9633743	·001980198
506	256036	129554216	22·4944438	7·9686271	·001976285
507	257049	130323843	22·5166605	7·9738731	·001972387
508	258064	131096512	22·5388553	7·9791122	·001968504
509	259081	131872229	22·5610283	7·9843444	·001964637
510	260100	132651000	22·5831796	7·9895697	·001960785
511	261121	133432831	22·6053091	7·9947883	·001956947
512	262144	134217728	22·6274170	8·0000000	·001953125
513	263169	135005697	22·6495033	8·0052049	·001949318
514	264196	135796744	22·6715681	8·0104032	·001945525
515	265225	136590875	22·6936114	8·0155946	·001941748
516	266256	137388096	22·7156334	8·0207794	·001937984
517	267289	138188413	22·7376341	8·0259574	·001934236
518	268324	138991832	22·7596134	8·0311287	·001930502
519	269361	139798359	22·7815715	8·0362935	·001926782
520	270400	140608000	22·8035085	8·0414515	·001923077
521	271441	141420761	22·8254244	8·0466030	·001919386
522	272484	142236648	22·8473193	8·0517479	·001915709
523	273529	143055667	22·8691933	8·0568862	001912046
524	274576	143877824	22·8910463	8·0620180	·001908397
525	275625	144703125	22·9128785	8·0671432	·001904762
526	276676	145531576	22·9346899	8·0722620	·001901141
527	277729	146363183	22·9564806	8·0773743	·001897533
528	278784	147197952	22·9782506	8·0824800	·001893939
529	279841	148035889	23·0000000	8·0875794	·001890359
530	280900	148877001	23·0217289	8·0926723	·001886792
531	281961	149721291	23·0434372	8·0977589	·001883239
532	283024	150568768	23·0651252	8·1028390	·001879699
533	284089	151419437	23·0867928	8·1079128	·001876173
534	285156	152273304	23·1084400	8·1129803	·001872659
535	286225	153130375	23·1300670	8·1180414	·001869159
536	287296	153990656	23·1516738	8·1230962	·001865672
537	288369	154854153	23·1732605	8·1281447	·001862197
538	289444	155720872	23·1948270	8·1331870	·001858736
539	290521	156590819	23·2163735	8·1382230	·001855288
540	291600	157464000	23·2379001	8·1432529	·001851852
541	292681	158340421	23·2594067	8·1482765	·001848429
542	293764	159220088	23·2808935	8·1532939	·001845018
543	294849	160103007	23·3023604	8·1583051	·001841621
544	295936	160989184	23·3238076	8·1633102	·001838235
545	297025	161878625	23·3452351	8·1683092	·001834862
546	298116	162771336	23·3666429	8·1733020	·001831502

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
547	299209	163667323	23·3880311	8·1783848	·001828154
548	300304	164566592	23·4093998	8·1833695	·001824818
549	301401	165469149	23·4307490	8·1882441	·001821494
550	302500	166375000	23·4520788	8·1932127	·001818182
551	303601	167284151	23·4733892	8·1981753	·001814882
552	304704	168196608	23·4946802	8·2031319	·001811594
553	305809	169112377	23·5159520	8·2080825	·001808318
554	306916	170031464	23·5372046	8·2130271	·001805054
555	308025	170953875	23·5584380	8·2179657	·001801802
556	309136	171879616	23·5796522	8·2228985	·001798561
557	310249	172808693	23·6008474	8·2278254	·001795332
558	311364	173741112	23·6220236	8·2327463	·001792115
559	312481	174676879	23·6431808	8·2376614	·001788909
560	313600	175616000	23·6643191	8·2425706	·001785714
561	314721	176558481	23·6854386	8·2474740	·001782531
562	315844	177504328	23·7065392	8·2523715	·001779359
563	316969	178453547	23·7276210	8·2572633	·001776199
564	318096	179406144	23·7486842	8·2621492	·001773050
565	319225	180362125	23·7697286	8·2670294	·001769912
566	320356	181321496	23·7907545	8·2719039	·001766784
567	321489	182284263	23·8117618	8·2767726	·001763668
568	322624	183250432	23·8327506	8·2816355	·001760563
569	323761	184220009	23·8537209	8·2864928	·001757469
570	324900	185193000	23·8746728	8·2913444	·001754386
571	326041	186169411	23·8956063	8·2961903	·001751313
572	327184	187149248	23·9165215	8·3010304	·001748252
573	328329	188132517	23·9374184	8·3058651	001745201
574	329476	189119224	23·9582971	8·3106941	·001742160
575	330625	190109375	23·9791576	8·3155175	·001739130
576	331776	191102976	24·0000000	8·3203353	·001736111
577	332929	192100033	24·0208243	8·3251475	·001733102
578	334084	193100552	24·0416306	8·3299542	·001730104
579	335241	194104539	24·0624188	8·3347553	·001727116
580	336400	195112000	24·0831891	8·3395509	·001724138
581	337561	196122941	24·1039416	8·3443410	·001721170
582	338724	197137368	24·1246762	8·3491256	·001718213
583	339889	198155287	24·1453929	8·3539047	·001715266
584	341056	199176704	24·1660919	8·3586784	·001712329
585	342225	200201625	24·1867732	8·3634466	·001709402
586	343396	201230056	24·2074369	8·3682095	·001706485
587	344569	202262003	24·2280829	8·3729668	·001703578
588	345744	203297472	24·2487113	8·3777188	·001700680
589	346921	204336469	24·2693222	8·3824653	·001697793
590	348100	205379000	24·2899156	8·3872065	·001694915
591	349281	206425071	24·3104996	8·3919423	·001692047
592	350464	207474688	24·3310501	8·3966729	·001689189
593	351649	208527857	24·3515913	8·4013981	·001686341
594	352836	209584584	24·3721152	8·4061180	·001683502
595	354025	210644875	24·3926218	8·4108326	·001680672
596	355216	211708736	24·4131112	8·4155419	·001677852
597	356409	212776173	24·4335834	8·4202460	·001675042
598	357604	213847192	24·4540385	8·4249448	·001672241
599	358801	214921799	24·4744765	8·4296383	·001669449
600	360000	216000000	24·4948974	8·4343267	·001666667
601	361201	217081801	24·5153013	8·4390098	·001663894
602	362404	218167208	24·5356883	8·4436877	·001661130
603	363609	219256227	24·5560583	8·4483605	·001658375
604	364816	220348864	24·5764115	8·4530281	·001655629
605	366025	221445125	24·5967478	8·4576906	·001652893
606	367236	222545016	24·6170673	8·4623479	·001650165
607	368449	223648543	24·6373700	8·4670001	·001647446
608	369664	224755712	24·6576560	8·4716471	·001644737

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
609	370881	225866529	24·6779254	8·4762892	·001642036
610	372100	226981000	24·6981781	8·4809261	·001639344
611	373321	228099131	24·7184142	8·4855579	·001636661
612	374544	229220928	25·7386338	8·4901848	·001633987
613	375769	230346397	24·7588368	8·4948065	·001631321
614	376996	231475544	24·7790234	8·4994233	·001628664
615	378225	232608375	24·7991935	8·5040350	·001626016
616	379456	233744896	24·8193473	8·5086417	·001623377
617	380689	234885113	24·8394847	8·5132435	·001620746
618	381924	236029032	24·8596058	8·5178403	·001618123
619	383161	237176659	24·8797106	8·5224331	·001615509
620	384400	238328000	24·8997992	8·5270189	·001612903
621	385641	239483061	24·9198716	8·5316009	·001610306
622	386884	240641848	24·9399278	8·5361780	·001607717
623	388129	241804367	24·9599679	8·5407501	·001605136
624	389376	242970624	24·9799920	8·5453173	·001602564
625	390625	244140625	25·0000000	8·5498797	·001600000
626	391876	245314376	25·0199920	8·5544372	·001597444
627	393129	246491883	25·0399681	8·5589899	·001594896
628	394384	247673152	25·0599282	8·5635377	·001592357
629	395641	248858189	25·0798724	8·5680807	·001589825
630	396900	250047000	25·0998008	8·5726189	·001587302
631	398161	251239591	25·1197134	8·5771523	·001584786
632	399424	252435968	25·1396102	8·5816809	·001582278
633	400689	253636137	25·1594913	8·5862047	·001579779
634	401956	254840104	25·1793566	8·5907238	·001577287
635	403225	256047875	25·1992063	8·5952380	·001574803
636	404496	257259456	25·2190404	8·5997476	·001572327
637	405769	258474853	25·2388589	8·6042525	·001569859
638	407044	259694072	25·2586619	8·6087526	·001567398
639	408321	260917119	25·2784493	8·6132480	·001564945
640	409600	262144000	25·2982213	8·6177388	·001562500
641	410881	263374721	25·3179778	8·6222248	·001560062
642	412164	264609288	25·3377189	8·6267063	·001557632
643	413449	265847707	25·3574447	8·6311830	·001555210
644	414736	267089984	25·3771551	8·6356551	·001552795
645	416125	268336125	25·3968502	8·6401226	·001550388
646	417316	269586136	25·4165302	8·6445855	·001547988
647	418609	270840023	25·4361947	8·6490437	·001545595
648	419904	272097792	25·4558441	8·6534974	·001543210
649	421201	273359449	25·4754784	8·6579465	·001540832
650	422500	274625000	25·4950976	8·6623911	·001538462
651	423801	275894451	25·5147016	8·6668310	·001536098
652	425104	277167808	25·5342907	8·6712665	·001533742
653	426409	278445077	25·5538647	8·6756974	·001531394
654	427716	279726264	25·5734237	8·6801237	·001529052
655	429025	281011375	25·5929678	8·6845456	·001526718
656	430336	282300416	25·6124969	8·6889630	·001524390
657	431639	283593393	25·6320112	8·6933759	·001522070
658	432964	284890312	25·6515107	8·6977843	·001519757
659	434281	286191179	25·6709953	8·7021882	·001517451
660	435600	287496000	25·6904652	8·7065877	·001515152
661	436921	288804781	25·7099203	8·7109827	·001512859
662	438244	290117528	25·7293607	8·7153734	·001510574
663	439569	291434247	25·7487864	8·7197596	·001508296
664	440896	292754944	25·7681975	8·7241414	·001506024
665	442225	294079625	25·7875939	8·7285187	·001503759
666	443556	295408296	25·8069758	8·7328918	·001501502
667	444889	296740963	25·8263431	8·7372604	·001499250
668	446224	298077632	25·8456960	8·7416246	·001497006
669	447561	299418309	25·8650343	8·7459846	.001494768
670	448900	300763000	25·8843582	8·7503401	·001492537

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
671	450241	302111711	25·9036677	8·7546913	·001490313
672	451584	303464448	25·9229628	8·7590383	·001488095
673	452929	304821217	25·9422435	8·7633809	·001485884
674	454276	306182024	25·9615100	8·7677192	·001483680
675	455625	307546875	25·9807621	8·7720532	·001481481
676	456976	308915776	26·0000000	8·7763830	·001479290
677	458329	310288733	26·0192237	8·7807084	·001477105
678	459684	311665752	26·0384331	8·7850296	·001474926
679	461041	313046839	26·0576284	8·7893466	·001472754
680	462400	314432000	26·0768096	8·7936593	·001470588
681	463761	315821241	26·0959767	8·7979679	·001468429
682	465124	317214568	26·1151297	8·8022721	·001466276
683	466489	318611987	26·1342687	8·8065722	·001464129
684	467856	320013504	26·1533937	8·8108681	·001461988
685	469225	321419125	26·1725047	8·8151598	·001459854
686	470596	322828856	26·1916017	8·8194474	·001457726
687	471969	324242703	26·2106848	8·8237307	·001455604
688	473344	325660672	26·2297541	8·8280099	·001453488
689	474721	327082769	26·2488095	8·8322850	·001451379
690	476100	328509000	26·2678511	8·8365559	·001449275
691	477481	329939371	26·2868789	8·8408227	·001447178
692	478864	331373888	26·3058929	8·8450854	·001445087
693	480249	332812557	26·3248932	8·8493440	·001443001
694	481636	334255384	26·3438797	8·8535985	·001440922
695	483025	335702375	26·3628527	8·8578489	·001438849
696	484416	337153536	26·3818119	8·8620952	·001436782
697	485809	338608873	26·4007576	8·8663375	·001434720
698	487204	340068392	26·4196896	8·8705757	·001432665
699	488601	341532099	26·4386081	8·8748099	·001430615
700	490000	343000000	26·4575131	8·8790400	·001428571
701	491401	344472101	26·4764046	8·8832661	·001426534
702	492804	345948408	26·4952826	8·8874882	·001424501
703	494209	347428927	26·5141472	8·8917063	·001422475
704	495616	348913664	26·5329983	8·8959204	·001420455
705	497025	350402625	26·5518361	8·9001304	·001418440
706	498436	351895816	26·5706605	8·9043366	·001416431
707	499849	353393243	26·5894716	8·9085387	·001414427
708	501264	354894912	26·6082694	8·9127369	·001412429
709	502681	356400829	26·6270539	8·9169311	·001410437
710	504100	357911000	26·6458252	8·9211214	·001408451
711	505521	359425431	26·6645833	8·9253078	·001406470
712	506944	360944128	26·6833281	8·9294902	·001404494
713	508369	362467097	26·7020598	8·9336687	·001402525
714	509796	363994344	26·7207784	8·9378433	·001400560
715	511225	365525875	26·7394839	8·9420140	·001398601
716	512656	367061696	26·7581763	8·9461809	001396648
717	514089	368601813	26·7768557	8·9503438	·001394700
718	515524	370146232	26·7955220	8·9545029	·001392758
719	516961	371694959	26·8141754	8·9586581	·001390821
720	518400	373248000	26·8328157	8·9628095	·001388889
721	519841	374805361	26·8514432	8·9669570	·001386963
722	521284	376367048	26·8700577	8·9711007	·001385042
723	522729	377933067	26·8886593	8·9752406	·001383126
724	524176	379503424	26·9072481	8·9793766	·001381215
725	525625	381078125	26·9258240	8·9835089	·001379310
726	527076	382657176	26·9443872	8·9876373	·001377410
727	528529	384240583	26·9629375	8·9917620	·001375516
728	529984	385828352	26·9814751	8·9958899	·001373626
729	531441	387420489	27·0000000	9·0000000	·001371742
730	532900	389017000	27·0185122	9·0041134	·001369863
731	534361	390617891	27·0370117	9·0082229	·001367989
732	535824	392223168	27·0554985	9·0123288	·001366120

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
733	537289	393832837	27·0739727	9·0164309	·001364256
734	538756	395446904	27·0924344	9·0205293	·001362398
735	540225	397065375	27·1108834	9·0246239	·001360544
736	541696	398688256	27·1293199	9·0287149	·001358696
737	543169	400315553	27·1477439	9·0328021	·001356852
738	544644	401947272	27·1661554	9·0368857	·001355014
739	546121	403583419	27·1845544	9·0409655	·001353180
740	547600	405224000	27·2029410	9·0450419	·001351351
741	549081	406869021	27·2213152	9·0491142	·001349528
742	550564	408518488	27·2396769	9·0531831	·001347709
743	552049	410172407	27·2580263	9·0572482	·001345895
744	553536	411830784	27·2763634	9·0613098	·001344086
745	555025	413493625	27·2946881	9·0653677	·001342282
746	556516	415160936	27·3130036	9·0694220	·001340483
747	558009	416832723	27·3313007	9·0734726	·001338688
748	559504	418508992	27·3495887	9·0775197	·001336898
749	561001	420189749	27·3678644	9·0815631	·001335113
750	562500	421875000	27·3861279	9·0856030	·001333333
751	564001	423564751	27·4043792	9·0896392	·001331558
752	565504	425259008	27·4226184	9·0936719	·001329787
753	567009	426957777	27·4408455	9·0977010	·001328021
754	568516	428661064	27·4590604	9·1017265	·001326260
755	570025	430368875	27·4772633	9·1057485	·001324503
756	571536	432081216	27·4954542	9·1097669	·001322751
757	573049	433798093	27·5136330	9·1137818	·001321004
758	574564	435519512	27·5317998	9·1177931	·001319261
759	576081	437245479	27·5499546	9·1218010	·001317523
760	577600	438976000	27·5680975	9·1258053	·001315789
761	579121	440711081	27·5862284	9·1298061	·001314060
762	580644	442450728	27·6043475	9·1338034	·001312336
763	582169	444194947	27·6224546	9·1377971	·001310616
764	583696	445943744	27·6405499	9·1417874	·001308901
765	585225	447697125	27·6586334	9·1457742	·001307190
766	586756	449455096	27·6767050	9·1497576	·001305483
767	588289	451217663	27·6947648	9·1537375	·001303781
768	589824	452984832	27·7128129	9·1577139	·001302083
769	591361	454756609	27·7308492	9·1616869	·001300390
770	592900	456533000	27·7488739	9·1656565	·001298701
771	594441	458314011	27·7668868	9·1696225	·001297017
772	595984	460099648	27·7848880	9·1735852	·001295337
773	597529	461889917	27·8028775	9·1775445	·001293661
774	599076	463684824	27·8208555	9·1815003	·001291990
775	600625	465484375	27·8388218	9·1854527	·001290323
776	602176	467288576	27·8567766	9·1894018	·001288660
777	603729	469097433	27·8747197	9·1933474	·001287001
778	605284	470910952	27·8926514	9·1972897	·001285347
779	606841	472729139	27·9105715	9·2012286	·001283697
780	608400	474552000	27·9284801	9·2051641	·001282051
781	609961	476379541	27·9463772	9·2090962	·001280410
782	611524	478211768	27·9642629	9·2130250	·001278772
783	613089	480048687	27·9821372	9·2169505	·001277139
784	614656	481890304	28·0000000	9·2208726	·001275510
785	616225	483736625	28·0178515	9·2247914	·001273885
786	617796	485587656	28·0356915	9·2287068	·001272265
787	619369	487443403	28·0535203	9·2326189	·001270648
788	620944	489303872	28·0713377	9·2365277	·001269036
789	622521	491169069	28·0891438	9·2404333	·001267427
790	624100	493039000	28·1069386	9·2443355	·001265823
791	625681	494913671	28·1247222	9·2482344	·001264223
792	627624	496793088	28·1424946	9·2521300	·001262626
793	628849	498677257	28·1602557	9·2560224	·001261034
794	630436	500566184	28·1780056	9·2599114	·001259446

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
795	632025	502459875	28·1957444	9·2637973	·001257862
796	633616	504358336	28·2134720	9·2676798	·001256281
797	635209	506261573	28·2311884	9·2715592	·001254705
798	636804	508169592	28·2488938	9·2754352	·001253133
799	638401	510082399	28·2665881	9·2793081	·001251364
800	640000	512000000	28·2842712	9·2831777	·001250000
801	641601	513922401	28·3019434	9·2870444	·001248439
802	643204	515849608	28·3196045	9·2909072	·001246883
803	644809	517781627	28·3372546	9·2947671	·001245330
804	646416	519718464	28·3548938	9·2986239	·001243781
805	648025	521660125	28·3725219	9·3024775	·001242236
806	649636	523606616	28·3901391	9·3063278	·001240695
807	651249	525557943	28·4077454	9·3101750	·001239157
808	652864	527514112	28·4253408	9·3140190	·001237624
809	654481	529475129	28·4429253	9·3178599	·001236094
810	656100	531441000	28·4604989	9·3216975	·001234568
811	657721	533411731	28·4780617	9·3255320	·001233046
812	659344	535387328	28·4956137	9·3293634	·001231527
813	660969	537367797	28·5131549	9·3331916	·001230012
814	662596	539353144	28·5306852	9·3370167	·001228501
815	664225	541343375	28·5482048	9·3408386	·001226994
816	665856	543338496	28·5657137	9·3446575	·001225490
817	667489	545338513	28·5832119	9·3484731	·001223990
818	669124	547343432	28·6006993	9·3522857	·001222494
819	670761	549353259	28·6181760	9·3560952	·001221001
820	672400	551368000	28·6356421	9·3599016	·001219512
821	674041	553387661	28·6530976	9·3637049	·001218027
822	675684	555412248	28·6705424	9·3675051	·001216545
823	677329	557441767	28·6879766	9·3713022	·001215067
824	678976	559476224	28·7054002	9·3750963	·001213592
825	680625	561515625	28·7228132	9·3788873	·001212121
826	682276	563559976	28·7402157	9·3826752	·001210654
827	683929	565609283	28·7576077	9·3864600	·001209190
828	685584	567663552	28·7749891	9·3902419	·001207729
829	687241	569722789	28·7923601	9·3940206	·001206273
830	688900	571787000	28·8097206	9·3977964	·001204819
831	690561	573856191	28·8270706	9·4015691	·001203369
832	692224	575930368	28·8444102	9·4053387	·001201923
833	693889	578009537	28·8617394	9·4091054	·001200480
834	695556	580093704	28·8790582	9·4128690	·001199041
835	697225	582182875	28·8963666	9·4166297	·001197605
836	698896	584277056	28·9136646	9·4203873	·001196172
837	700569	586376253	28·9309523	9·4241420	·001194743
838	702244	588480472	28·9482297	9·4278936	·001193317
839	703921	590589719	28·9654967	9·4316423	·001191895
840	705600	592704000	28·9827535	9·4353880	·001190476
841	707281	594823321	29·0000000	9·4391307	·001189061
842	708964	596947688	29·0172363	9·4428704	·001187648
843	710649	599077107	29·0344623	9·4466072	·001186240
844	712336	601211584	29·0516781	9·4503410	·001184834
845	714025	603351125	29·0688837	9·4540719	·001183432
846	715716	605495736	29·0860791	9·4577999	·001182033
847	717409	607645423	29·1032644	9·4615249	·001180638
848	719104	609800192	29·1204396	9·4652470	·001179245
849	720801	611960049	29·1376046	9·4689661	·001177856
850	722500	614125000	29·1547595	9·4726824	·001176471
851	724201	616295051	29·1719043	9·4763957	·001175088
852	725904	618470208	29·1890390	9·4801061	·001173709
853	727609	620650477	29·2061637	9·4838136	·001172333
854	729316	622835864	29·2232784	9·4875182	·001170960
855	731025	625026375	29·2403830	9·4912200	·001169591
856	732736	627222016	29·2574777	9·4949188	·001168224

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
857	734449	629422793	29·2745623	9·4986147	·001166861
858	736164	631628712	29·2916370	9·5023078	·001165501
859	737881	633839779	29·3087018	9·5059980	·001164144
860	739600	636056000	29·3257566	9·5096854	·001162791
861	741321	638277381	29·3428015	9·5133699	·001161440
862	743044	640503928	29·3598365	9·5170515	·001160093
863	744769	642735647	29·3768616	9·5207303	·001158749
864	746496	644972544	29·3938769	9·5244063	·001157407
865	748225	647214625	29·5108823	9·5280794	·001156069
866	749956	649461896	29·4278779	9·5317497	·001154734
867	751689	651714363	29·4448637	9·5354172	·001153403
868	753424	653972032	29·4618397	9·5390818	·001152074
869	755161	656234909	29·4788059	9·5427437	·001150748
870	756900	658503000	29·4957624	9·5464027	·001149425
871	758641	660776311	29·5127091	9·5500589	·001148106
872	760384	663054848	29·5296461	9·5537123	·001146789
873	762129	665338617	29·5465734	9·5573630	·001145475
874	763876	667627624	29·5634910	9·5610108	·001144165
875	765625	669921875	29·5803989	9·5646559	·001142857
876	767376	672221376	29·5972972	9·5682782	·001141553
877	769129	674526133	29·6141858	9·5719377	·001140251
878	770884	676836152	29·6310648	9·5755745	·001138952
879	772641	679151439	29·6479342	9·5792085	·001137656
880	774400	681472000	29·6647939	9·5828397	·001136364
881	776161	683797841	29·6816442	9·5864682	·001135074
882	777924	686128968	29·6984848	9·5900939	·001133787
883	779689	688465387	29·7153159	9·5937169	·001132503
884	781456	690807104	29·7321375	9·5973373	·001131222
885	783225	693154125	29·7489496	9·6009548	·001129944
886	784996	695506456	29·7657521	9·6045696	·001128668
887	786769	697864103	29·7825452	9·6081817	001127396
888	788544	700227072	29·7993289	9·6117911	·001126126
889	790321	702595369	29·8161030	9·6153977	·001124859
890	792100	704969000	29·8328678	9·6190017	·001123596
891	793881	707347971	29·8496231	9·6226030	·001122334
892	795664	709732288	29·8663690	9·6262016	·001121076
893	797449	712121957	29·8831056	9·6297975	·001119821
894	799236	714516984	29·8998328	9·6333907	·001118568
895	801025	716917375	29·9165506	9·6369812	·001117818
896	802816	719323136	29·9332591	9·6405690	·001116071
897	804609	721734273	29·9499583	9·6441542	·001114827
898	806404	724150792	29·9666481	9·6477367	·001113586
899	808201	726572699	29·9833287	9·6513166	·001112347
900	810000	729000000	30·0000000	9·6548938	·001111111
901	811801	731432701	30·0166621	9·6584684	·001109878
902	813604	733870808	30·0333148	9·6620403	·001108647
903	815409	736314327	30·0499584	9·6656096	·001107420
904	817216	738763264	30·0665928	9·6691762	·001106195
905	819025	741217625	30·0832179	9·6727403	·001104972
906	820836	743677416	30·0998339	9·6763017	·001103753
907	822649	746142643	30·1164407	9·6798604	·001102536
908	824464	748613312	30·1330383	9·6834166	001101322
909	826281	751089429	30·1496269	9·6869701	·001100110
910	828100	753571000	30·1662063	9·6905211	·001098901
911	829921	756058031	30·1827765	9·6940694	·001097695
912	831744	758550528	30·1993377	9·6976151	·001096491
913	833569	761048497	30·2158899	9·7011583	·001095290
914	835396	763551944	30·2324329	9·7046989	·001094092
915	837225	766060875	30·2489669	9·7082369	·001092896
916	839056	768575296	30·2654919	9·7117723	·001091703
917	840889	771095213	30·2820079	9·7153051	·001090513
918	842724	773620632	30·2985148	9·7188354	·001089325

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
919	844561	776151559	30·3150128	9·7223631	·001088139
920	846400	778688000	30·3315018	9·7258593	·001086957
921	848241	781229961	30·3479818	9·7294109	·001085776
922	850084	783777448	30·3644529	9·7329309	·001084599
923	851929	786330467	30·3809151	9·7364484	·001083423
924	853776	788889024	30·3973683	9·7399634	·001082251
925	855625	791453125	30·4138127	9·7434758	·001081081
926	857476	794022776	30·4302481	9·7469857	·001079914
927	859329	796597983	30·4466747	9·7504930	·001078749
928	861184	799178752	30·4630924	9·7539979	·001077586
929	863041	801765089	30·4795013	9·7575002	·001076426
930	864900	804357000	30·4959014	9·7610001	·001075269
931	866761	806954491	30·5122926	9·7644974	·001074114
932	868624	809557568	30·5286750	9·7679922	·001072961
933	870489	812166237	30·5450487	9·7714845	·001071811
934	872356	814780504	30·5614136	9·7749743	·001070664
935	874225	817400375	30·5777697	9·7784616	·001069519
936	876096	820025856	30·5941171	9·7819466	·001068376
937	877969	822656953	30·6104557	9·7854288	·001067236
938	879844	825293672	30·6267857	9·7889087	·001066098
939	881721	827936019	30·6431069	9·7923861	·001064963
940	883600	830584000	30·6594194	9·7958611	·001063830
941	885481	833237621	30·6757233	9·7993336	·001062699
942	887364	835896888	30·6920185	9·8028036	·001061571
943	889249	838561807	30·7083051	9·8062711	·001060445
944	891136	841232384	30·7245830	9·8097362	·001059322
945	893025	843908625	30·7408523	9·8131989	·001058201
946	894916	846590536	30·7571130	9·8166591	·001057082
947	896809	849278123	30·7733651	9·8201169	·001055966
948	898704	851971392	30·7896086	9·8235723	·001054852
949	900601	854670349	30·8058436	9·8270252	·001053741
950	902500	857375000	30·8220700	9·8304757	·001052632
951	904401	860085351	30·8382879	9·8339238	·001051525
952	906304	862801408	30·8544972	9·8373695	·001050420
953	908209	865523177	30·8706981	9·8408127	·001049318
954	910116	868250664	30·8868904	9·8442536	·001048218
955	912025	870983875	30·9030743	9·8476920	·001047120
956	913936	873722816	30·9192497	9·8511280	·001046025
957	915849	876467493	30·9354166	9·8545617	·001044932
958	917764	879217912	30·9515751	9·8579929	·001043841
959	919681	881974079	30·9677251	9·8614218	·001042753
960	921600	884736000	30·9838668	9·8648483	·001041667
961	923521	887503681	31·0000000	9·8682724	·001040583
962	925444	890277128	31·0161248	9·8716941	·001039501
963	927369	893056347	31·0322413	9·8751135	·001038422
964	929296	895841344	31·0483494	9·8785305	·001037344
965	931225	898632125	31·0644491	9·8819451	·001036269
966	933156	901428696	31·0805405	9·8853574	·001035197
967	935089	904231063	31·0966236	9·8887673	·001034126
968	937024	907039232	31·1126984	9·8921749	·001033058
969	938961	909853209	31·1287648	9·8955801	·001031992
979	940900	912673000	31·1448230	9·8989830	·001030928
971	942841	915498611	31·1608729	9·9023835	·001029866
972	944784	918330048	31·1769145	9·9057817	·001028807
973	946729	921167317	31·1929479	9·9091776	·001027749
974	948676	924010424	31·2089731	9·9125712	·001026694
975	950625	926859375	31·2249900	9·9159624	·001025641
976	952576	929714176	31·2409987	9·9193513	·001024590
977	954529	932574833	31·2569992	9·9227379	·001023541
978	956484	935441352	31·2729915	9·9261222	·001022495
979	958441	938313739	31·2889757	9·9295042	·001021450
980	960400	941192000	31·3049517	9·9328839	001020408

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
981	962361	944076141	31·3209195	9·9362613	·001019168
982	964324	946966168	31·3368792	9·9396363	·001018330
983	966289	949862087	31·3528308	9·9430092	·001017294
984	968256	952763904	31·3687743	9·9463797	·001016260
985	970225	955671625	31·3847097	9·9497479	·001015228
986	972196	958585256	31.4006369	9·9531138	·001014199
987	974169	961504803	31·4165561	9·9564775	·001013171
988	976144	964430272	31·4324673	9·9598389	·001012146
989	978121	967361669	31·4483704	9·9631981	·001011122
990	980100	970299000	31·4642654	9·9665549	·001010101
991	982081	973242271	31·4801525	9·9699095	·001009082
992	984064	976191488	31·4960315	9·9732619	·001008065
993	986049	979146657	31·5119025	9·9766120	·001007049
994	988036	982107784	31·5277655	9·9799599	·001006036
995	990025	985074875	31·5436206	9·9833055	001005025
996	992016	988047936	31·5594677	9·9866488	·001004016
997	994009	991026973	31·5753068	9·9899900	·001003009
998	996004	994011992	31·5911380	9·9933289	·001002004
999	998001	997002999	31·6069613	9·9966656	·001001001
1000	1000000	1000000000	31·6227766	10·0000000	·001000000
1001	1002001	1003003001	31·6385840	10·0033222	·0009990010
1002	1004004	1006012008	31·6543836	10·0066622	·0009980040
1003	1006009	1009027027	31,6701752	10·0099899	·0009970090
1004	1008016	1012048064	31·6859590	10·0133155	·0009960159
1005	1010025	1015075125	31·7017349	10·0166389	·0009950249
1006	1012036	1018108216	31·7175030	10·0199601	·0009940358
1007	1014049	1021147343	31·7332633	10·0232791	·0009930487
1008	1016064	1024192512	31·7490157	10·0265958	·0009920635
1009	1018081	1027243729	31·7647603	10·0299104	·0009910803
1010	1020100	1030301000	31·7804972	10·0332228	·0009900990
1011	1022121	1033364331	31·7962262	10·0365330	·0009891197
1012	1024144	1036433728	31·8119474	10·0398410	·0009881423
1013	1026169	1039509197	31·8276609	10·0431469	·0009871668
1014	1028196	1042590744	31·8433666	10·0464506	·0009861933
1015	1030225	1045678375	31·8590646	10·0497521	·0009852217
1016	1032256	1048772096	31·8747549	10·0530514	·0009842520
1017	1034289	1051871913	31·8904374	10·0563485	0009832842
1018	1036324	1054977832	31·9061123	10·0596435	0009823183
1019	1038361	1058089859	31·9217794	10·0629364	0009813543
1020	1040400	1061208000	31·9374388	10·0662271	0009803922
1021	1042441	1064332261	31·9530906	10·0695156	0009794319
1022	1044484	1067462648	31·9687347	10·0728020	0009784736
1023	1046529	1070599167	31·9843712	10·0760863	0009775171
1024	1048576	1073741824	32·0000000	10·0793684	0009765625
1025	1050625	1076890625	32·0156212	10·0826484	0009756098
1026	1052676	1080045576	32·0312348	10·0859262	0009746589
1027	1054729	1083206683	32·0468407	10·0892019	0009737098
1028	1056784	1086373952	32·0624391	10·0924755	0009727626
1029	1058841	1089547389	32·0780298	10·0957469	·0009718173
1030	1060900	1092727000	32·0936131	10·0990163	·0009708738
1031	1062961	1095912791	32·1091887	10·1022835	·0009699321
1032	1065024	1099104768	32·1247568	10·1055487	·0009689922
1033	1067089	1102302937	32·1403173	10·1088117	·0009680542
1034	1069156	1105507304	32·1558704	10·1120726	·0009671180
1035	1071225	1108717875	32·1714159	10·1153314	·0009661836
1036	1073296	1111934656	32·1869539	10·1185882	·0009652510
1037	1075369	1115157653	32·2024844	10·1218428	0009643202
1038	1077444	1118386872	32·2180074	10·1250953	0009633911
1039	1079521	1121622319	32·2335229	10·1283457	·0009624639
1040	1081600	1124864000	32·2490310	10·1315941	·0009615385
1041	1083681	1128111921	32·2645316	10·1348403	·0009606148
1042	1085764	1131366088	32·2800248	10·1380845	·0009596929

TABLE XII.

LOGARITHMS OF NUMBERS

FROM 1 TO 10000.

A

TABLE,

CONTAINING

THE LOGARITHMS OF NUMBERS

FROM 1 TO 10,000.

NUMBERS FROM 1 TO 100 AND THEIR LOGARITHMS,

WITH THEIR INDICES.

No.	Logarithm.	No.	Logarithm.	No.	Logarithm.	No.	Logarithm.	No.	Logarithm.
1	0·000000	21	1·322219	41	1·612784	61	1·785330	81	1·908485
2	0·301030	22	1·342423	42	1·623249	62	1·792392	82	1·913814
3	0·477121	23	1·361728	43	1·633468	63	1·799341	83	1·919078
4	0·602060	24	1·380211	44	1·643453	64	1·806180	84	1·924279
5	0·698970	25	1·397940	45	1·653213	65	1·812913	85	1·929419
6	0·778151	26	1·414973	46	1·662758	66	1·819544	86	1·934498
7	0·845098	27	1·431364	47	1·672098	67	1·826075	87	1·939519
8	0·903090	28	1·447158	48	1·681241	68	1·832509	88	1·944483
9	0·954243	29	1·462398	49	1·690196	69	1·838849	89	1·949390
10	1·000000	30	1·477121	50	1·698970	70	1·845098	90	1·954243
11	1·041393	31	1·491362	51	1·707570	71	1·851258	91	1·959041
12	1·079181	32	1·505150	52	1·716003	72	1·857332	92	1·963788
13	1·113943	33	1·518514	53	1·724276	73	1·863323	93	1·968483
14	1·146128	34	1·531479	54	1·732394	74	1·869232	94	1·973128
15	1·176091	35	1·544068	55	1·740363	75	1.875061	95	1·977724
16	1·204120	36	1·556303	56	1·748188	76	1·880814	96	1·982271
17	1·230449	37	1·568202	57	1·755875	77	1·886491	97	1·986772
18	1·255273	38	1·579784	58	1·763428	78	1·892095	98	1·991226
19	1·278754	39	1·591065	59	1·770852	79	1·897627	99	1·995635
20	1·301030	40	1·602060	60	1·778151	80	1·903090	100	2·000000

NOTE.—In the following part of the Table, the characteristics are omitted, as they can be very easily supplied. Thus, the characteristic of the logarithm of every integer number, consisting only of one number, is 0; of two figures, 1; of three figures, 2; of four figures, 3; being always a unit less than the number of figures contained in the integer number,

No.	0	1	2	3	4	5	6	7	8	9	Diff
100	000000	000434	000868	001301	001734	002166	002598	003029	003461	003891	432
1	4321	4751	5181	5609	6038	6466	6894	7321	7748	8174	428
2	8600	9026	9451	9876	010300	010724	011147	011570	011993	012415	424
3	012837	013259	013680	014100	4521	4940	5360	5779	6197	6616	420
4	7033	7451	7868	8284	8700	9116	9532	9947	020361	020775	416
5	021189	021603	022016	022428	022841	023252	023664	024075	4486	4896	412
6	5306	5715	6125	6533	6942	7350	7757	8164	8571	8978	408
7	9384	9789	030195	030600	031004	031408	031812	032216	032619	033021	404
8	033424	033826	4227	4628	5029	5430	5830	6230	6629	7028	400
9	7426	7825	8223	8620	9017	9414	9811	040207	040602	040998	397
110	041393	041787	042182	042576	042969	043362	043755	044148	044540	044932	393
1	5323	5714	6105	6495	6885	7275	7664	8053	8442	8830	390
2	9218	9606	9993	050380	050766	051153	051538	051924	052309	052694	386
3	053078	053463	053846	4230	4613	4996	5378	5760	6142	6524	383
4	6905	7286	7666	8046	8426	8805	9185	9563	9942	060320	379
5	060698	061075	061452	061829	062206	062582	062958	063333	063709	4083	376
6	4458	4832	5206	5580	5953	6326	6699	7071	7443	7815	373
7	8186	8557	8928	9298	9668	070038	070407	070776	071145	071514	370
8	071882	072250	072617	072985	073352	3718	4085	4451	4816	5182	366
9	5547	5912	6276	6640	7004	7368	7731	8094	8457	8819	363
120	079181	079543	079904	080266	080626	080987	081347	081707	082067	082426	360
1	082785	083144	083503	3861	4219	4576	4934	5291	5647	6004	357
2	6360	6716	7071	7426	7781	8136	8490	8845	9198	9552	355
3	9905	090258	090611	090963	091315	091667	092018	092370	092721	093071	352
4	093422	3772	4122	4471	4820	5169	5518	5866	6215	6562	349
5	6910	7257	7604	7951	8298	8644	8990	9335	9681	100026	346
6	100371	100715	101059	101403	101747	102091	102434	102777	103119	3462	343
7	3804	4146	4487	4828	5169	5510	5851	6191	6531	6871	341
8	7210	7549	7888	8227	8565	8903	9241	9579	9916	110253	338
9	110590	110926	111263	111599	111934	112270	112605	112940	113275	3609	335
130	113943	114277	114611	114944	115278	115611	115943	116276	116608	116940	333
1	7271	7603	7934	8265	8595	8926	9256	9586	9915	120245	330
2	120574	120903	121231	121560	121888	122216	122544	122871	123198	3525	328
3	3852	4178	4504	4830	5156	5481	5806	6131	6456	6781	325
4	7105	7429	7753	8076	8399	8722	9045	9368	9690	130012	323
5	130334	130655	130977	131298	131619	131939	132260	132580	132900	3219	321
6	3539	3858	4177	4496	4814	5133	5451	5769	6086	6403	318
7	6721	7037	7354	7671	7987	8303	8618	8934	9249	9564	316
8	9879	140194	140508	140822	141136	141450	141763	142076	142389	142702	314
9	143015	3327	3639	3951	4263	4574	4885	5196	5507	5818	311
140	146128	146438	146748	147058	147367	147676	147985	148294	148603	148911	309
1	9219	9527	9835	150142	150449	150756	151063	151370	151676	151982	307
2	152288	152594	152900	3205	3510	3815	4120	4424	4728	5032	305
3	5336	5640	5943	6246	6549	6852	7154	7457	7759	8061	303
4	8362	8664	8965	9266	9567	9868	160168	160469	160769	161068	301
5	161368	161667	161967	162266	162564	162863	3161	3460	3758	4055	299
6	4353	4650	4947	5244	5541	5838	6134	6430	6726	7022	297
7	7317	7613	7908	8203	8497	8792	9086	9380	9674	9968	295
8	170262	170555	170848	171141	171434	171726	172019	172311	172603	172895	293
9	3186	3478	3769	4060	4351	4641	4932	5222	5512	5802	291
150	176091	176381	176670	176959	177248	177536	177825	178113	178401	178689	289
1	8977	9264	9552	9839	180126	180413	180699	180986	181272	181558	287
2	181844	182129	182415	182700	2985	3270	3555	3839	4123	4407	285
3	4691	4975	5259	5542	5825	6108	6391	6674	6956	7239	283
4	7521	7803	8084	8366	8647	8928	9209	9490	9771	190051	281
5	190332	190612	190892	191171	191451	191730	192010	192289	192567	2846	279
6	3125	3403	3681	3959	4237	4514	4792	5069	5346	5623	278
7	5900	6176	6453	6729	7005	7281	7556	7832	8107	8382	276
8	8657	8932	9206	9481	9755	200029	200303	200577	200850	201124	274
9	201397	201670	201943	202216	202488	2761	3033	3305	3577	3848	272
No.	0	1	2	3	4	5	6	7	8	9	Diff

No.	0	1	2	3	4	5	6	7	8	9	Diff.
160	204120	204391	204663	204934	205204	205475	205746	206016	206286	206556	271
1	6826	7096	7365	7634	7904	8173	8441	8710	8979	9247	269
2	9515	9783	210051	210319	210586	210853	211121	211388	211654	211921	267
3	212188	212454	2720	2986	3252	3518	3783	4049	4314	4579	266
4	4844	5109	5373	5638	5902	6166	6430	6694	6957	7221	264
5	7484	7747	8010	8273	8536	8798	9060	9323	9585	9846	262
6	220108	220370	220631	220892	221153	221414	221675	221936	222196	222456	261
7	2716	2976	3236	3496	3755	4015	4274	4533	4792	5051	259
8	5309	5568	5826	6084	6342	6600	6858	7115	7372	7630	258
9	7887	8144	8400	8657	8913	9170	9426	9682	9938	230193	256
170	230449	230704	230960	231215	231470	231724	231979	232234	232488	232742	255
1	2996	3250	3504	3757	4011	4264	4517	4770	5023	5276	253
2	5528	5781	6033	6285	6537	6789	7041	7292	7544	7795	252
3	8046	8297	8548	8799	9049	9299	9550	9800	240050	240300	250
4	240549	240799	241048	241297	241546	241795	242044	242293	2541	2790	249
5	3038	3286	3534	3782	4030	4277	4525	4772	5019	5266	248
6	5513	5759	6006	6252	6499	6745	6991	7237	7482	7728	246
7	7973	8219	8464	8709	8954	9198	9443	9687	9932	250176	245
8	250420	250664	250908	251151	251395	251638	251881	252125	252368	2610	243
9	2853	3096	3338	3580	3822	4064	4306	4548	4790	5031	242
180	255273	255514	255755	255996	256237	256477	256718	256958	257198	257439	241
1	7679	7918	8158	8398	8637	8877	9116	9355	9594	9833	239
2	260071	260310	260548	260787	261025	261263	261501	261739	261976	262214	238
3	2451	2688	2925	3162	3399	3636	3873	4109	4346	4582	237
4	4818	5054	5290	5525	5761	5996	6232	6467	6702	6937	235
5	7172	7406	7641	7875	8110	8344	8578	8812	9046	9279	234
6	9513	9746	9980	270213	270446	270679	270912	271144	271377	271609	233
7	271842	272074	272306	2538	2770	3001	3233	3464	3696	3927	232
8	4158	4389	4620	4850	5081	5311	5542	5772	6002	6232	230
9	6462	6692	6921	7151	7380	7609	7838	8067	8296	8525	229
190	278754	278982	279211	279439	279667	279895	280123	280351	280578	280806	228
1	281033	281261	281488	281715	281942	282169	2396	2622	2849	3075	227
2	3301	3527	3753	3979	4205	4431	4656	4882	5107	5332	226
3	5557	5782	6007	6232	6456	6681	6905	7130	7354	7578	225
4	7802	8026	8249	8473	8696	8920	9143	9366	9589	9812	223
5	290035	290257	290480	290702	290925	291147	291369	291591	291813	292034	222
6	2256	2478	2699	2920	3141	3363	3584	3804	4025	4246	221
7	4466	4687	4907	5127	5347	5567	5787	6007	6226	6446	220
8	6665	6884	7104	7323	7542	7761	7979	8198	8416	8635	219
9	8853	9071	9289	9507	9725	9943	300161	300378	300595	300813	218
200	301030	301247	301464	301681	301898	302114	302331	302547	302764	302980	217
1	3196	3412	3628	3844	4059	4275	4491	4706	4921	5136	216
2	5351	5566	5781	5996	6211	6425	6639	6854	7068	7282	215
3	7496	7710	7924	8137	8351	8564	8778	8991	9204	9417	213
4	9630	9843	310056	310268	310481	310693	310906	311118	311330	311542	212
5	311754	311966	2177	2389	2600	2812	3023	3234	3445	3656	211
6	3867	4078	4289	4499	4710	4920	5130	5340	5551	5760	210
7	5970	6180	6390	6599	6809	7018	7227	7436	7646	7854	209
8	8063	8272	8481	8689	8898	9106	9314	9522	9730	9938	208
9	320146	320354	320562	320769	320977	321184	321391	321598	321805	322012	207
210	322219	322426	322633	322839	323046	323252	323458	323665	323871	324077	206
1	4282	4488	4694	4899	5105	5310	5516	5721	5926	6131	205
2	6336	6541	6745	6950	7155	7359	7563	7767	7972	8176	204
3	8380	8583	8787	8991	9194	9398	9601	9805	330008	330211	203
4	330414	330617	330819	331022	331225	331427	331630	331832	2034	2236	202
5	2438	2640	2842	3044	3246	3447	3649	3850	4051	4253	202
6	4454	4655	4856	5057	5257	5458	5658	5859	6059	6260	201
7	6460	6660	6860	7060	7260	7459	7659	7858	8058	8257	200
8	8456	8656	8855	9054	9253	9451	9650	9849	340047	340246	199
9	340444	340642	340841	341039	341237	341435	341632	341830	2028	2225	198
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220	342423	342620	342817	343014	343212	343409	343606	343802	343999	344196	197
1	4392	4589	4785	4981	5178	5374	5570	5766	5962	6157	196
2	6353	6549	6744	6939	7135	7330	7525	7720	7915	8110	195
3	8305	8500	8694	8889	9083	9278	9472	9666	9860	350054	194
4	350248	350442	350636	350829	351023	351216	351410	351603	351796	1989	193
5	2183	2375	2568	2761	2954	3147	3339	3532	3724	3916	193
6	4108	4301	4493	4685	4876	5068	5260	5452	5643	5834	192
7	6026	6217	6408	6599	6790	6981	7172	7363	7554	7744	191
8	7935	8125	8316	8506	8696	8886	9076	9266	9456	9646	190
9	9835	360025	360215	360404	360593	360783	360972	361161	361350	361539	189
230	361728	361917	362105	362294	362482	362671	362859	363048	363236	363424	188
1	3612	3800	3988	4176	4363	4551	4739	4926	5113	5301	188
2	5488	5675	5862	6049	6236	6423	6610	6796	6983	7169	187
3	7356	7542	7729	7915	8101	8287	8473	8659	8845	9030	186
4	9216	9401	9587	9772	9958	370143	370328	370513	370698	370883	185
5	371068	371253	371437	371622	371806	1991	2175	2360	2544	2728	184
6	2912	3096	3280	3464	3647	3831	4015	4198	4382	4565	184
7	4748	4932	5115	5298	5481	5664	5846	6029	6212	6394	183
8	6577	6759	6942	7124	7306	7488	7670	7852	8034	8216	182
9	8398	8580	8761	8943	9124	9306	9487	9668	9849	380030	181
240	380211	380392	380573	380754	380934	381115	381296	381476	381656	381837	181
1	2017	2197	2377	2557	2737	2917	3097	3277	3456	3636	180
2	3815	3995	4174	4353	4533	4712	4891	5070	5249	5428	179
3	5606	5785	5964	6142	6321	6499	6677	6856	7034	7212	178
4	7390	7568	7746	7923	8101	8279	8456	8634	8811	8989	178
5	9166	9343	9520	9698	9875	390051	390228	390405	390582	390759	177
6	390935	391112	391288	391464	391641	1817	1993	2169	2345	2521	176
7	2697	2873	3048	3224	3400	3575	3751	3926	4101	4277	176
8	4452	4627	4802	4977	5152	5326	5501	5676	5850	6025	175
9	6199	6374	6548	6722	6896	7071	7245	7419	7592	7766	174
250	397940	398114	398287	398461	398634	398808	398981	399154	399328	399501	173
1	9674	9847	400020	400192	400365	400538	400711	400883	401056	401228	173
2	401401	401573	1745	1917	2089	2261	2433	2605	2777	2949	172
3	3121	3292	3464	3635	3807	3978	4149	4320	4492	4663	171
4	4834	5005	5176	5346	5517	5688	5858	6029	6199	6370	171
5	6540	6710	6881	7051	7221	7391	7561	7731	7901	8070	170
6	8240	8410	8579	8749	8918	9087	9257	9426	9595	9764	169
7	9933	410102	410271	410440	410609	410777	410946	411114	411283	411451	169
8	411620	1788	1956	2124	2293	2461	2629	2796	2964	3132	168
9	3300	3467	3635	3803	3970	4137	4305	4472	4639	4806	167
260	414973	415140	415307	415474	415641	415808	415974	416141	416308	416474	167
1	6641	6807	6973	7139	7306	7472	7638	7804	7970	8135	166
2	8301	8467	8633	8798	8964	9129	9295	9460	9625	9791	165
3	9956	420121	420286	420451	420616	420781	420945	421110	421275	421439	165
4	421604	1768	1933	2097	2261	2426	2590	2754	2918	3082	164
5	3246	3410	3574	3737	3901	4065	4228	4392	4555	4718	164
6	4882	5045	5208	5371	5534	5697	5860	6023	6186	6349	163
7	6511	6674	6836	6999	7161	7324	7486	7648	7811	7973	162
8	8135	8297	8459	8621	8783	8944	9106	9268	9429	9591	162
9	9752	9914	430075	430236	430398	430559	430720	430881	431042	431203	161
270	431364	431525	431685	431846	432007	432167	432328	432488	432649	432809	161
1	2969	3130	3290	3450	3610	3770	3930	4090	4249	4409	160
2	4569	4729	4888	5048	5207	5367	5526	5685	5844	6004	159
3	6163	6322	6481	6640	6799	6957	7116	7275	7433	7592	159
4	7751	7909	8067	8226	8384	8542	8701	8859	9017	9175	158
5	9333	9491	9648	9806	9964	440122	440279	440437	440594	440752	158
6	440909	441066	441224	441381	441538	1695	1852	2009	2166	2323	157
7	2480	2637	2793	2950	3106	3263	3419	3576	3732	3889	157
8	4045	4201	4357	4513	4669	4825	4981	5137	5293	5449	156
9	5604	5760	5915	6071	6226	6382	6537	6692	6848	7003	155
No.	0	1	2	3	4	5	6	7	8	9	Dif.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
280	447158	447313	447468	447623	447778	447933	448088	448242	448397	448552	155
1	8706	8861	9015	9170	9324	9478	9633	9787	9941	450095	154
2	450249	450403	450557	450711	450865	451018	451172	451326	451479	1633	154
3	1786	1940	2093	2247	2400	2553	2706	2859	3012	3165	153
4	3318	3471	3624	3777	3930	4082	4235	4387	4540	4692	153
5	4845	4997	5150	5302	5454	5606	5758	5910	6062	6214	152
6	6366	6518	6670	6821	6973	7125	7276	7428	7579	7731	152
7	7882	8033	8184	8336	8487	8638	8789	8940	9091	9242	151
8	9392	9543	9694	9845	9995	460146	460296	460447	460597	460748	151
9	460898	461048	461198	461348	461499	1649	1799	1948	2098	2248	150
290	462398	462548	462697	462847	462997	463146	463296	463445	463594	463744	150
1	3893	4042	4191	4340	4490	4639	4788	4936	5085	5234	149
2	5383	5532	5680	5829	5977	6126	6274	6423	6571	6719	149
3	6868	7016	7164	7312	7460	7608	7756	7904	8052	8200	148
4	8347	8495	8643	8790	8938	9085	9233	9380	9527	9675	148
5	9822	9969	470116	470263	470410	470557	470704	470851	470998	471145	147
6	471292	471438	1585	1732	1878	2025	2171	2318	2464	2610	146
7	2756	2903	3049	3195	3341	3487	3633	3779	3925	4071	146
8	4216	4362	4508	4653	4799	4944	5090	5235	5381	5526	146
9	5671	5816	5962	6107	6252	6397	6542	6687	6832	6976	145
300	477121	477266	477411	477555	477700	477844	477989	478133	478278	478422	145
1	8566	8711	8855	8999	9143	9287	9431	9575	9719	9863	144
2	480007	480151	480294	480438	480582	480725	480869	481012	481156	481299	144
3	1443	1586	1729	1872	2016	2159	2302	2445	2588	2731	143
4	2874	3016	3159	3302	3445	3587	3730	3872	4015	4157	143
5	4300	4442	4585	4727	4869	5011	5153	5295	5437	5579	142
6	5721	5863	6005	6147	6289	6430	6572	6714	6855	6997	142
7	7138	7280	7421	7563	7704	7845	7986	8127	8269	8410	141
8	8551	8692	8833	8974	9114	9255	9396	9537	9677	9818	141
9	9958	490099	490239	490380	490520	490661	490801	490941	491081	491222	140
310	491362	491502	491642	491782	491922	492062	492201	492341	492481	492621	140
1	2760	2900	3040	3179	3319	3458	3597	3737	3876	4015	139
2	4155	4294	4433	4572	4711	4850	4989	5128	5267	5406	139
3	5544	5683	5822	5960	6099	6238	6376	6515	6653	6791	139
4	6930	7068	7206	7344	7483	7621	7759	7897	8035	8173	138
5	8311	8448	8586	8724	8862	8999	9137	9275	9412	9550	138
6	9687	9824	9962	500099	500236	500374	500511	500648	500785	500922	137
7	501059	501196	501333	1470	1607	1744	1880	2017	2154	2291	137
8	2427	2564	2700	2837	2973	3109	3246	3382	3518	3655	136
9	3791	3927	4063	4199	4335	4471	4607	4743	4878	5014	136
320	505150	505286	505421	505557	505693	505828	505964	506099	506234	506370	136
1	6505	6640	6776	6911	7046	7181	7316	7451	7586	7721	135
2	7856	7991	8126	8260	8395	8530	8664	8799	8934	9068	135
3	9203	9337	9471	9606	9740	9874	510009	510143	510277	510411	134
4	510545	510679	510813	510947	511081	511215	1349	1482	1616	1750	134
5	1883	2017	2151	2284	2418	2551	2684	2818	2951	3084	133
6	3218	3351	3484	3617	3750	3883	4016	4149	4282	4415	133
7	4548	4681	4813	4946	5079	5211	5344	5476	5609	5741	133
8	5874	6006	6139	6271	6403	6535	6668	6800	6932	7064	132
9	7196	7328	7460	7592	7724	7855	7987	8119	8251	8382	132
330	518514	518646	518777	518909	519040	519171	519303	519434	519566	519697	131
1	9828	9959	520090	520221	520353	520484	520615	520745	520876	521007	131
2	521138	521269	1400	1530	1661	1792	1922	2053	2183	2314	131
3	2444	2575	2705	2835	2966	3096	3226	3356	3486	3616	130
4	3746	3876	4006	4136	4266	4396	4526	4656	4785	4915	130
5	5045	5174	5304	5434	5563	5693	5822	5951	6081	6210	129
6	6339	6469	6598	6727	6856	6985	7114	7243	7372	7501	129
7	7630	7759	7888	8016	8145	8274	8402	8531	8660	8788	129
8	8917	9045	9174	9302	9430	9559	9687	9815	9943	530072	128
9	530200	530328	530456	530584	530712	530840	530968	531096	531223	1351	128
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff
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1	2754	2882	3009	3136	3264	3391	3518	3645	3772	3899	127
2	4026	4153	4280	4407	4534	4661	4787	4914	5041	5167	127
3	5294	5421	5547	5674	5800	5927	6053	6180	6306	6432	126
4	6558	6685	6811	6937	7063	7189	7315	7441	7567	7693	126
5	7819	7945	8071	8197	8322	8448	8574	8699	8825	8951	126
6	9076	9202	9327	9452	9578	9703	9829	9954	540079	540204	125
7	540329	540455	540580	540705	540830	540955	541080	541205	1330	1454	125
8	1579	1704	1829	1953	2078	2203	2327	2452	2576	2701	125
9	2825	2950	3074	3199	3323	3447	3571	3696	3820	3944	124
350	544068	544192	544316	544440	544564	544688	544812	544936	545060	545183	124
1	5307	5431	5555	5678	5802	5925	6049	6172	6296	6419	124
2	6543	6666	6789	6913	7036	7159	7282	7405	7529	7652	123
3	7775	7898	8021	8144	8267	8389	8512	8635	8758	8881	123
4	9003	9126	9249	9371	9494	9616	9739	9861	9984	550106	123
5	550228	550351	550473	550595	550717	550840	550962	551084	551206	1328	122
6	1450	1572	1694	1816	1938	2060	2181	2303	2425	2547	122
7	2668	2790	2911	3033	3155	3276	3398	3519	3640	3762	121
8	3883	4004	4126	4247	4368	4489	4610	4731	4852	4973	121
9	5094	5215	5336	5457	5578	5699	5820	5940	6061	6182	121
360	556303	556423	556544	556664	556785	556905	557026	557146	557267	557387	120
1	7507	7627	7748	7868	7988	8108	8228	8349	8469	8589	120
2	8709	8829	8948	9068	9188	9308	9428	9548	9667	9787	120
3	9907	560026	560146	560265	560385	560504	560624	560743	560863	560982	119
4	561101	1221	1340	1459	1578	1698	1817	1936	2055	2174	119
5	2293	2412	2531	2650	2769	2887	3006	3125	3244	3362	119
6	3481	3600	3718	3837	3955	4074	4192	4311	4429	4548	119
7	4666	4784	4903	5021	5139	5257	5376	5494	5612	5730	118
8	5848	5966	6084	6202	6320	6437	6555	6673	6791	6909	118
9	7026	7144	7262	7379	7497	7614	7732	7849	7967	8084	118
370	568202	568319	568436	568554	568671	568788	568905	569023	569140	569257	117
1	9374	9491	9608	9725	9842	9959	570076	570193	570309	570426	117
2	570543	570660	570776	570893	571010	571126	1243	1359	1476	1592	117
3	1709	1825	1942	2058	2174	2291	2407	2523	2639	2755	116
4	2872	2988	3104	3220	3336	3452	3568	3684	3800	3915	116
5	4031	4147	4263	4379	4494	4610	4726	4841	4957	5072	116
6	5188	5303	5419	5534	5650	5765	5880	5996	6111	6226	115
7	6341	6457	6572	6687	6802	6917	7032	7147	7262	7377	115
8	7492	7607	7722	7836	7951	8066	8181	8295	8410	8525	115
9	8639	8754	8868	8983	9097	9212	9326	9441	9555	9669	114
380	579784	579898	580012	580126	580241	580355	580469	580583	580697	580811	114
1	580925	581039	1153	1267	1381	1495	1608	1722	1836	1950	114
2	2063	2177	2291	2404	2518	2631	2745	2858	2972	3085	114
3	3199	3312	3426	3539	3652	3765	3879	3992	4105	4218	113
4	4331	4444	4557	4670	4783	4896	5009	5122	5235	5348	113
5	5461	5574	5686	5799	5912	6024	6137	6250	6362	6475	113
6	6587	6700	6812	6925	7037	7149	7262	7374	7486	7599	112
7	7711	7823	7935	8047	8160	8272	8384	8496	8608	8720	112
8	8832	8944	9056	9167	9279	9391	9503	9615	9726	9838	112
9	9950	590061	590173	590284	590396	590507	590619	590730	590842	590953	112
390	591065	591176	591287	591399	591510	591621	591732	591843	591955	592066	111
1	2177	2288	2399	2510	2621	2732	2843	2954	3064	3175	111
2	3286	3397	3508	3618	3729	3840	3950	4061	4171	4282	111
3	4393	4503	4614	4724	4834	4945	5055	5165	5276	5386	110
4	5496	5606	5717	5827	5937	6047	6157	6267	6377	6487	110
5	6597	6707	6817	6927	7037	7146	7256	7366	7476	7586	110
6	7695	7805	7914	8024	8134	8243	8353	8462	8572	8681	110
7	8791	8900	9009	9119	9228	9337	9446	9556	9665	9774	109
8	9883	9992	600101	600210	600319	600428	600537	600646	600755	600864	109
9	600973	601082	1191	1299	1408	1517	1625	1734	1843	1951	109
No.	0	1			4	5	6	7	8	9	Dif

No.	0	1	2	3	4	5	6	7	8	9	Diff
400	602060	602169	602277	602386	602494	602603	602711	602819	602928	603036	108
1	3144	3253	3361	3469	3577	3686	3794	3902	4010	4118	108
2	4226	4334	4442	4550	4658	4766	4874	4982	5089	5197	108
3	5305	5413	5521	5628	5736	5844	5951	6059	6166	6274	108
4	6381	6489	6596	6704	6811	6919	7026	7133	7241	7348	107
5	7455	7562	7669	7777	7884	7991	8098	8205	8312	8419	107
6	8526	8633	8740	8847	8954	9061	9167	9274	9381	9488	107
7	9594	9701	9808	9914	610021	610128	610234	610341	610447	610554	107
8	610660	610767	610873	610979	1086	1192	1298	1405	1511	1617	106
9	1723	1829	1936	2042	2148	2254	2360	2466	2572	2678	106
410	612784	612890	612996	613102	613207	613313	613419	613525	613630	613736	106
1	3842	3947	4053	4159	4264	4370	4475	4581	4686	4792	106
2	4897	5003	5108	5213	5319	5424	5529	5634	5740	5845	105
3	5950	6055	6160	6265	6370	6476	6581	6686	6790	6895	105
4	7000	7105	7210	7315	7420	7525	7629	7734	7839	7943	105
5	8048	8153	8257	8362	8466	8571	8676	8780	8884	8989	105
6	9093	9198	9302	9406	9511	9615	9719	9824	9928	620032	104
7	620136	620240	620344	620448	620552	620656	620760	620864	620968	1072	104
8	1176	1280	1384	1488	1592	1695	1799	1903	2007	2110	104
9	2214	2318	2421	2525	2628	2732	2835	2939	3042	3146	104
420	623249	623353	623456	623559	623663	623766	623869	623973	624076	624179	103
1	4282	4385	4488	4591	4695	4798	4901	5004	5107	5210	103
2	5312	5415	5518	5621	5724	5827	5929	6032	6135	6238	103
3	6340	6443	6546	6648	6751	6853	6956	7058	7161	7263	103
4	7366	7468	7571	7673	7775	7878	7980	8082	8185	8287	102
5	8389	8491	8593	8695	8797	8900	9002	9104	9206	9308	102
6	9410	9512	9613	9715	9817	9919	630021	630123	630224	630326	102
7	630428	630530	630631	630733	630835	630936	1038	1139	1241	1342	102
8	1444	1545	1647	1748	1849	1951	2052	2153	2255	2356	101
9	2457	2559	2660	2761	2862	2963	3064	3165	3266	3367	101
430	633468	633569	633670	633771	633872	633973	634074	634175	634276	634376	101
1	4477	4578	4679	4779	4880	4981	5081	5182	5283	5383	101
2	5484	5584	5685	5785	5886	5986	6087	6187	6287	6388	100
3	6488	6588	6688	6789	6889	6989	7089	7189	7290	7390	100
4	7490	7590	7690	7790	7890	7990	8090	8190	8290	8389	100
5	8489	8589	8689	8789	8888	8988	9088	9188	9287	9387	100
6	9486	9586	9686	9785	9885	9984	640084	640183	640283	640382	99
7	640481	640581	640680	640779	640879	640978	1077	1177	1276	1375	99
8	1474	1573	1672	1771	1871	1970	2069	2168	2267	2366	99
9	2465	2563	2662	2761	2860	2959	3058	3156	3255	3354	99
440	643453	643551	643650	643749	643847	643946	644044	644143	644242	644340	98
1	4439	4537	4636	4734	4832	4931	5029	5127	5226	5324	98
2	5422	5521	5619	5717	5815	5913	6011	6110	6208	6306	96
3	6404	6502	6600	6698	6796	6894	6992	7089	7187	7285	98
4	7383	7481	7579	7676	7774	7872	7969	8067	8165	8262	98
5	8360	8458	8555	8653	8750	8848	8945	9043	9140	9237	97
6	9335	9432	9530	9627	9724	9821	9919	650016	650113	650210	97
7	650308	650405	650502	650599	650696	650793	650890	0987	1084	1181	97
8	1278	1375	1472	1569	1666	1762	1859	1956	2053	2150	97
9	2246	2343	2440	2536	2633	2730	2826	2923	3019	3116	97
450	653213	653309	653405	653502	653598	653695	653791	653888	653984	654080	96
1	4177	4273	4369	4465	4562	4658	4754	4850	4946	5042	96
2	5138	5235	5331	5427	5523	5619	5715	5810	5906	6002	96
3	6098	6194	6290	6386	6482	6577	6673	6769	6864	6960	96
4	7056	7152	7247	7343	7438	7534	7629	7725	7820	7916	96
5	8011	8107	8202	8298	8393	8488	8584	8679	8774	8870	95
6	8965	9060	9155	9250	9346	9441	9536	9631	9726	9821	95
7	9916	660011	660106	660201	660296	660391	660486	660581	660676	660771	95
8	660865	0960	1055	1150	1245	1339	1434	1529	1623	1718	95
9	1813	1907	2002	2096	2191	2286	2380	2475	2569	2663	95
No.	0	1	2	3	4	5	6	7	8	9	Diff

No.	0	1	2	3	4	5	6	7	8	9	Diff.
460	662758	662852	662947	663041	663135	663230	663324	663418	663512	663607	94
1	3701	3795	3889	3983	4078	4172	4266	4360	4454	4548	94
2	4642	4736	4830	4924	5018	5112	5206	5299	5393	5487	94
3	5581	5675	5769	5862	5956	6050	6143	6237	6331	6424	94
4	6518	6612	6705	6799	6892	6986	7079	7173	7266	7360	94
5	7453	7546	7640	7733	7826	7920	8013	8106	8199	8293	93
6	8386	8479	8572	8665	8759	8852	8945	9038	9131	9224	93
7	9317	9410	9503	9596	9689	9782	9875	9967	670060	670153	93
8	670246	670339	670431	670524	670617	670710	670802	670895	0988	1080	93
9	1173	1265	1358	1451	1543	1636	1728	1821	1913	2005	93
470	672098	672190	672283	672375	672467	672560	672652	672744	672836	672929	92
1	3021	3113	3205	3297	3390	3482	3574	3666	3758	3850	92
2	3942	4034	4126	4218	4310	4402	4494	4586	4677	4769	92
3	4861	4953	5045	5137	5228	5320	5412	5503	5595	5687	92
4	5778	5870	5962	6053	6145	6236	6328	6419	6511	6602	92
5	6694	6785	6876	6968	7059	7151	7242	7333	7424	7516	91
6	7607	7698	7789	7881	7972	8063	8154	8245	8336	8427	91
7	8518	8609	8700	8791	8882	8973	9064	9155	9246	9337	91
8	9428	9519	9610	9700	9791	9882	9973	680063	680154	680245	91
9	680336	680426	680517	680607	680698	680789	680879	0970	1060	1151	91
480	681241	681332	681422	681513	681603	681693	681784	681874	681964	682055	90
1	2145	2235	2326	2416	2506	2596	2686	2777	2867	2957	90
2	3047	3137	3227	3317	3407	3497	3587	3677	3767	3857	90
3	3947	4037	4127	4217	4307	4396	4486	4576	4666	4756	90
4	4845	4935	5025	5114	5204	5294	5383	5473	5563	5652	90
5	5742	5831	5921	6010	6100	6189	6279	6368	6458	6547	89
6	6636	6726	6815	6904	6994	7083	7172	7261	7351	7440	89
7	7529	7618	7707	7796	7886	7975	8064	8153	8242	8331	89
8	8420	8509	8598	8687	8776	8865	8953	9042	9131	9220	89
9	9309	9398	9486	9575	9664	9753	9841	9930	690019	690107	89
490	690196	690285	690373	690462	690550	690639	690728	690816	690905	690993	89
1	1081	1170	1258	1347	1435	1524	1612	1700	1789	1877	88
2	1965	2053	2142	2230	2318	2406	2494	2583	2671	2759	88
3	2847	2935	3023	3111	3199	3287	3375	3463	3551	3639	88
4	3727	3815	3903	3991	4078	4166	4254	4342	4430	4517	88
5	4605	4693	4781	4868	4956	5044	5131	5219	5307	5394	88
6	5482	5569	5657	5744	5832	5919	6007	6094	6182	6269	87
7	6356	6444	6531	6618	6706	6793	6880	6968	7055	7142	87
8	7229	7317	7404	7491	7578	7665	7752	7839	7926	8014	87
9	8101	8188	8275	8362	8449	8535	8622	8709	8796	8883	87
500	698970	699057	699144	699231	699317	699404	699491	699578	699664	699751	87
1	9838	9924	700011	700098	700184	700271	700358	700444	700531	700617	87
2	700704	700790	0877	0963	1050	1136	1222	1309	1395	1482	86
3	1568	1654	1741	1827	1913	1999	2086	2172	2258	2344	86
4	2431	2517	2603	2689	2775	2861	2947	3033	3119	3205	86
5	3291	3377	3463	3549	3635	3721	3807	3893	3979	4065	86
6	4151	4236	4322	4408	4494	4579	4665	4751	4837	4922	86
7	5008	5094	5179	5265	5350	5436	5522	5607	5693	5778	86
8	5864	5949	6035	6120	6206	6291	6376	6462	6547	6632	85
9	6718	6803	6888	6974	7059	7144	7229	7315	7400	7485	85
510	707570	707655	707740	707826	707911	707996	708081	708166	708251	708336	85
1	8421	8506	8591	8676	8761	8846	8931	9015	9100	9185	85
2	9270	9355	9440	9524	9609	9694	9779	9863	9948	710033	85
3	710117	710202	710287	710371	710456	710540	710625	710710	710794	0879	85
4	0963	1048	1132	1217	1301	1385	1470	1554	1639	1723	84
5	1807	1892	1976	2060	2144	2229	2313	2397	2481	2566	84
6	2650	2734	2818	2902	2986	3070	3154	3238	3323	3407	84
7	3491	3575	3659	3742	3826	3910	3994	4078	4162	4246	84
8	4330	4414	4497	4581	4665	4749	4833	4916	5000	5084	84
9	5167	5251	5335	5418	5502	5586	5669	5753	5836	5920	84
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
520	716003	716087	716170	716254	716337	716421	716504	716588	716671	716754	83
1	6838	6921	7004	7088	7171	7254	7338	7421	7504	7587	83
2	7671	7754	7837	7920	8003	8086	8169	8253	8336	8419	83
3	8502	8585	8668	8751	8834	8917	9000	9083	9165	9248	83
4	9331	9414	9497	9580	9663	9745	9828	9911	9994	720077	83
5	720159	720242	720325	720407	720490	720573	720655	720738	720821	0903	83
6	0986	1068	1151	1233	1316	1398	1481	1563	1646	1728	82
7	1811	1893	1975	2058	2140	2222	2305	2387	2469	2552	82
8	2634	2716	2798	2881	2963	3045	3127	3209	3291	3374	82
9	3456	3538	3620	3702	3784	3866	3948	4030	4112	4194	82
530	724276	724358	724440	724522	724604	724685	724767	724849	724931	725013	82
1	5095	5176	5258	5340	5422	5503	5585	5667	5748	5830	82
2	5912	5993	6075	6156	6238	6320	6401	6483	6564	6646	82
3	6727	6809	6890	6972	7053	7134	7216	7297	7379	7460	81
4	7541	7623	7704	7785	7866	7948	8029	8110	8191	8273	81
5	8354	8435	8516	8597	8678	8759	8841	8922	9003	9084	81
6	9165	9246	9327	9408	9489	9570	9651	9732	9813	9893	81
7	9974	730055	730136	730217	730298	730378	730459	730540	730621	730702	81
8	730782	0863	0944	1024	1105	1186	1266	1347	1428	1508	81
9	1589	1669	1750	1830	1911	1991	2072	2152	2233	2313	81
540	732394	732474	732555	732635	732715	732796	732876	732956	733037	733117	80
1	3197	3278	3358	3438	3518	3598	3679	3759	3839	3919	80
2	3999	4079	4160	4240	4320	4400	4480	4560	4640	4720	80
3	4800	4880	4960	5040	5120	5200	5279	5359	5439	5519	80
4	5599	5679	5759	5838	5918	5998	6078	6157	6237	6317	80
5	6397	6476	6556	6635	6715	6795	6874	6954	7034	7113	80
6	7193	7272	7352	7431	7511	7590	7670	7749	7829	7908	79
7	7987	8067	8146	8225	8305	8384	8463	8543	8622	8701	79
8	8781	8860	8939	9018	9097	9177	9256	9335	9414	9493	79
9	9572	9651	9731	9810	9889	9968	740047	740126	740205	740284	79
550	740363	740442	740521	740600	740678	740757	740836	740915	740994	741073	79
1	1152	1230	1309	1388	1467	1546	1624	1703	1782	1860	79
2	1939	2018	2096	2175	2254	2332	2411	2489	2568	2647	79
3	2725	2804	2882	2961	3039	3118	3196	3275	3353	3431	78
4	3510	3588	3667	3745	3823	3902	3980	4058	4136	4215	78
5	4293	4371	4449	4528	4606	4684	4762	4840	4919	4997	78
6	5075	5153	5231	5309	5387	5465	5543	5621	5699	5777	78
7	5855	5933	6011	6089	6167	6245	6323	6401	6479	6556	78
8	6634	6712	6790	6868	6945	7023	7101	7179	7256	7334	78
9	7412	7489	7567	7645	7722	7800	7878	7955	8033	8110	78
560	748188	748266	748343	748421	748498	748576	748653	748731	748808	748885	77
1	8963	9040	9118	9195	9272	9350	9427	9504	9582	9659	77
2	9736	9814	9891	9968	750045	750123	750200	750277	750354	750431	77
3	750508	750586	750663	750740	0817	0894	0971	1048	1125	1202	77
4	1279	1356	1433	1510	1587	1664	1741	1818	1895	1972	77
5	2048	2125	2202	2279	2356	2433	2509	2586	2663	2740	77
6	2816	2893	2970	3047	3123	3200	3277	3353	3430	3506	77
7	3583	3660	3736	3813	3889	3966	4042	4119	4195	4272	77
8	4348	4425	4501	4578	4654	4730	4807	4883	4960	5036	76
9	5112	5189	5265	5341	5417	5494	5570	5646	5722	5799	76
570	755875	755951	756027	756103	756180	756256	756332	756408	756484	756560	76
1	6636	6712	6788	6864	6940	7016	7092	7168	7244	7320	76
2	7396	7472	7548	7624	7700	7775	7851	7927	8003	8079	76
3	8155	8230	8306	8382	8458	8533	8609	8685	8761	8836	76
4	8912	8988	9063	9139	9214	9290	9366	9441	9517	9592	76
5	9668	9743	9819	9894	9970	760045	760121	760196	760272	760347	75
6	760422	760498	760573	760649	760724	0799	0875	0950	1025	1101	75
7	1176	1251	1326	1402	1477	1552	1627	1702	1778	1853	75
8	1928	2003	2078	2153	2228	2303	2378	2453	2529	2604	75
9	2679	2754	2829	2904	2978	3053	3128	3203	3278	3353	75
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
580	763428	763503	763578	763653	763727	763802	763877	763952	764027	764101	75
1	4176	4251	4326	4400	4475	4550	4624	4699	4774	4848	75
2	4923	4998	5072	5147	5221	5296	5370	5445	5520	5594	75
3	5669	5743	5818	5892	5966	6041	6115	6190	6264	6338	74
4	6413	6487	6562	6636	6710	6785	6859	6933	7007	7082	74
5	7156	7230	7304	7379	7453	7527	7601	7675	7749	7823	74
6	7898	7972	8046	8120	8194	8268	8342	8416	8490	8564	74
7	8638	8712	8786	8860	8934	9008	9082	9156	9230	9303	74
8	9377	9451	9525	9599	9673	9746	9820	9894	9968	770042	74
9	770115	770189	770263	770336	770410	770484	770557	770631	770705	0778	74
590	770852	770926	770999	771073	771146	771220	771293	771367	771440	771514	74
1	1587	1661	1734	1808	1881	1955	2028	2102	2175	2248	73
2	2322	2395	2468	2542	2615	2688	2762	2835	2908	2981	73
3	3055	3128	3201	3274	3348	3421	3494	3567	3640	3713	73
4	3786	3860	3933	4006	4079	4152	4225	4298	4371	4444	73
5	4517	4590	4663	4736	4809	4882	4955	5028	5100	5173	73
6	5246	5319	5392	5465	5538	5610	5683	5756	5829	5902	73
7	5974	6047	6120	6193	6265	6338	6411	6483	6556	6629	73
8	6701	6774	6846	6919	6992	7064	7137	7209	7282	7354	73
9	7427	7499	7572	7644	7717	7789	7862	7934	8006	8079	72
600	778151	778224	778296	778368	778441	778513	778585	778658	778730	778802	72
1	8874	8947	9019	9091	9163	9236	9308	9380	9452	9524	72
2	9596	9669	9741	9813	9885	9957	780029	780101	780173	780245	72
3	780317	780389	780461	780533	780605	780677	0749	0821	0893	[illegible]	72
4	1037	1109	1181	1253	1324	1396	1468	1540	1612	1684	72
5	1755	1827	1899	1971	2042	2114	2186	2258	2329	[illegible]	72
6	2473	2544	2616	2688	2759	2831	2902	2974	3046	3117	72
7	3189	3260	3332	3403	3475	3546	3618	3689	3761	3832	71
8	3904	3975	4046	4118	4189	4261	4332	4403	4475	4546	71
9	4617	4689	4760	4831	4902	4974	5045	5116	5187	5259	71
610	785330	785401	785472	785543	785615	785686	785757	785828	785899	785970	71
1	6041	6112	6183	6254	6325	6396	6467	6538	6609	6680	71
2	6751	6822	6893	6964	7035	7106	7177	7248	7319	7390	71
3	7460	7531	7602	7673	7744	7815	7885	7956	8027	8098	71
4	8168	8239	8310	8381	8451	8522	8593	8663	8734	8804	71
5	8875	8946	9016	9087	9157	9228	9299	9369	9440	9510	71
6	9581	9651	9722	9792	9863	9933	790004	790074	790144	790215	70
7	790285	790356	790426	790496	790567	790637	0707	0778	0848	0918	70
8	0988	1059	1129	1199	1269	1340	1410	1480	1550	1620	70
9	1691	1761	1831	1901	1971	2041	2111	2181	2252	2322	70
620	792392	792462	792532	792602	792672	792742	792812	792882	792952	793022	70
1	3092	3162	3231	3301	3371	3441	3511	3581	3651	3721	70
2	3790	3860	3930	4000	4070	4139	4209	4279	4349	4418	70
3	4488	4558	4627	4697	4767	4836	4906	4976	5045	5115	70
4	5185	5254	5324	5393	5463	5532	5602	5672	5741	5811	70
5	5880	5949	6019	6088	6158	6227	6297	6366	6436	6505	69
6	6574	6644	6713	6782	6852	6921	6990	7060	7129	7198	69
7	7268	7337	7406	7475	7545	7614	7683	7752	7821	7890	69
8	7960	8029	8098	8167	8236	8305	8374	8443	8513	8582	69
9	8651	8720	8789	8858	8927	8996	9065	9134	9203	9272	69
630	799341	799409	799478	799547	799616	799685	799754	799823	799892	799961	69
1	800029	800098	800167	800236	800305	800373	800442	800511	800580	800648	69
2	0717	0786	0854	0923	0992	1061	1129	1198	1266	1335	69
3	1404	1472	1541	1609	1678	1747	1815	1884	1952	2021	69
4	2089	2158	2226	2295	2363	2432	2500	2568	2637	2705	68
5	2774	2842	2910	2979	3047	3116	3184	3252	3321	3389	68
6	3457	3525	3594	3662	3730	3798	3867	3935	4003	4071	68
7	4139	4208	4276	4344	4412	4480	4548	4616	4685	4753	68
8	4821	4889	4957	5025	5093	5161	5229	5297	5365	5433	68
9	5501	5569	5637	5705	5773	5841	5908	5976	6044	6112	68
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1	6858	6926	6994	7061	7129	7197	7264	7332	7400	7467	68
2	7535	7603	7670	7738	7806	7873	7941	8008	8076	8143	68
3	8211	8279	8346	8414	8481	8549	8616	8684	8751	8818	67
4	8886	8953	9021	9088	9156	9223	9290	9358	9425	9492	67
5	9560	9627	9694	9762	9829	9896	9964	810031	810098	810165	67
6	810233	810300	810367	810434	810501	810569	810636	0703	0770	0837	67
7	0904	0971	1039	1106	1173	1240	1307	1374	1441	1508	67
8	1575	1642	1709	1776	1843	1910	1977	2044	2111	2178	67
9	2245	2312	2379	2445	2512	2579	2646	2713	2780	2847	67
650	812913	812980	813047	813114	813181	813247	813314	813381	813448	813514	67
1	3581	3648	3714	3781	3848	3914	3981	4048	4114	4181	67
2	4248	4314	4381	4447	4514	4581	4647	4714	4780	4847	67
3	4913	4980	5046	5113	5179	5246	5312	5378	5445	5511	66
4	5578	5644	5711	5777	5843	5910	5976	6042	6109	6175	66
5	6241	6308	6374	6440	6506	6573	6639	6705	6771	6838	66
6	6904	6970	7036	7102	7169	7235	7301	7367	7433	7499	66
7	7565	7631	7698	7764	7830	7896	7962	8028	8094	8160	66
8	8226	8292	8358	8424	8490	8556	8622	8688	8754	8820	66
9	8885	8951	9017	9083	9149	9215	9281	9346	9412	9478	66
660	819544	819610	819676	819741	819807	819873	819939	820004	820070	820136	66
1	820201	820267	820333	820399	820464	820530	820595	0661	0727	0792	66
2	0858	0924	0989	1055	1120	1186	1251	1317	1382	1448	66
3	1514	1579	1645	1710	1775	1841	1906	1972	2037	2103	65
4	2168	2233	2299	2364	2430	2495	2560	2626	2691	2756	65
5	2822	2887	2952	3018	3083	3148	3213	3279	3344	3409	65
6	3474	3539	3605	3670	3735	3800	3865	3930	3996	4061	65
7	4126	4191	4256	4321	4386	4451	4516	4581	4646	4711	65
8	4776	4841	4906	4971	5036	5101	5166	5231	5296	5361	65
9	5426	5491	5556	5621	5686	5751	5815	5880	5945	6010	65
670	826075	826140	826204	826269	826334	826399	826464	826528	826593	826658	65
1	6723	6787	6852	6917	6981	7046	7111	7175	7240	7305	65
2	7369	7434	7499	7563	7628	7692	7757	7821	7886	7951	65
3	8015	8080	8144	8209	8273	8338	8402	8467	8531	8595	64
4	8660	8724	8789	8853	8918	8982	9046	9111	9175	9239	64
5	9304	9368	9432	9497	9561	9625	9690	9754	9818	9882	64
6	9947	830011	830075	830139	830204	830268	830332	830396	830460	830525	64
7	830589	0653	0717	0781	0845	0909	0973	1037	1102	1166	64
8	1230	1294	1358	1422	1486	1550	1614	1678	1742	1806	64
9	1870	1934	1998	2062	2126	2189	2253	2317	2381	2445	64
680	832509	832573	832637	832700	832764	832828	832892	832956	833020	833083	64
1	3147	3211	3275	3338	3402	3466	3530	3593	3657	3721	64
2	3784	3848	3912	3975	4039	4103	4166	4230	4294	4357	64
3	4421	4484	4548	4611	4675	4739	4802	4866	4929	4993	64
4	5056	5120	5183	5247	5310	5373	5437	5500	5564	5627	63
5	5691	5754	5817	5881	5944	6007	6071	6134	6197	6261	63
6	6324	6387	6451	6514	6577	6641	6704	6767	6830	6894	63
7	6957	7020	7083	7146	7210	7273	7336	7399	7462	7525	63
8	7588	7652	7715	7778	7841	7904	7967	8030	8093	8156	63
9	8219	8282	8345	8408	8471	8534	8597	8660	8723	8786	63
690	838849	838912	838975	839038	839101	839164	839227	839289	839352	839415	63
1	9478	9541	9604	9667	9729	9792	9855	9918	9981	840043	63
2	840106	840169	840232	840294	840357	840420	840482	840545	840608	0671	63
3	0733	0796	0859	0921	0984	1046	1109	1172	1234	1297	63
4	1359	1422	1485	1547	1610	1672	1735	1797	1860	1922	63
5	1985	2047	2110	2172	2235	2297	2360	2422	2484	2547	62
6	2609	2672	2734	2796	2859	2921	2983	3046	3108	3170	62
7	3233	3295	3357	3420	3482	3544	3606	3669	3731	3793	62
8	3855	3918	3980	4042	4104	4166	4229	4291	4353	4415	62
9	4477	4539	4601	4664	4726	4788	4850	4912	4974	5036	62
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No.	0	1	2	3	4	5	6	7	8	9	Diff.
700	845098	845160	845222	845284	845346	845408	845470	845532	845594	845656	62
1	5718	5780	5842	5904	5966	6028	6090	6151	6213	6275	62
2	6337	6399	6461	6523	6585	6646	6708	6770	6832	6894	62
3	6955	7017	7079	7141	7202	7264	7326	7388	7449	7511	62
4	7573	7634	7696	7758	7819	7881	7943	8004	8066	8128	62
5	8189	8251	8312	8374	8435	8497	8559	8620	8682	8743	62
6	8805	8866	8928	8989	9051	9112	9174	9235	9297	9358	61
7	9419	9481	9542	9604	9665	9726	9788	9849	9911	9972	61
8	850033	850095	850156	850217	850279	850340	850401	850462	850524	850585	61
9	0646	0707	0769	0830	0891	0952	1014	1075	1136	1197	61
710	851258	851320	851381	851442	851503	851564	851625	851686	851747	851809	61
1	1870	1931	1992	2053	2114	2175	2236	2297	2358	2419	61
2	2480	2541	2602	2663	2724	2785	2846	2907	2968	3029	61
3	3090	3150	3211	3272	3333	3394	3455	3516	3577	3637	61
4	3698	3759	3820	3881	3941	4002	4063	4124	4185	4245	61
5	4306	4367	4428	4488	4549	4610	4670	4731	4792	4852	61
6	4913	4974	5034	5095	5156	5216	5277	5337	5398	5459	61
7	5519	5580	5640	5701	5761	5822	5882	5943	6003	6064	61
8	6124	6185	6245	6306	6366	6427	6487	6548	6608	6668	60
9	6729	6789	6850	6910	6970	7031	7091	7152	7212	7272	60
720	857332	857393	857453	857513	857574	857634	857694	[illegible]	[illegible]	[illegible]	[illegible]
1	7935	7995	8056	8116	8176	8236	8297	[illegible]	[illegible]	[illegible]	[illegible]
2	8537	8597	8657	8718	8778	8838	8898	[illegible]	9018	[illegible]	[illegible]
3	9138	9198	9258	9318	9379	9439	9499	[illegible]	[illegible]	[illegible]	[illegible]
4	9739	9799	9859	9918	9978	860038	860098	[illegible]	[illegible]	[illegible]	[illegible]
5	860338	860398	860458	860518	860578	0637	0697	0757	0817	0877	60
6	0937	0996	1056	1116	1176	1236	1295	1355	1415	1475	60
7	1534	1594	1654	1714	1773	1833	1893	1952	2012	2072	60
8	2131	2191	2251	2310	2370	2430	2489	2549	2608	2668	60
9	2728	2787	2847	2906	2966	3025	3085	3144	3204	3263	60
730	863323	863382	863442	863501	863561	863620	863680	863739	863799	863858	59
1	3917	3977	4036	4096	4155	4214	4274	4333	4392	4452	59
2	4511	4570	4630	4689	4748	4808	4867	4926	4985	5045	59
3	5104	5163	5222	5282	5341	5400	5459	5519	5578	5637	59
4	5696	5755	5814	5874	5933	5992	6051	6110	6169	6228	59
5	6287	6346	6405	6465	6524	6583	6642	6701	6760	6819	59
6	6878	6937	6996	7055	7114	7173	7232	7291	7350	7409	59
7	7467	7526	7585	7644	7703	7762	7821	7880	7939	7998	59
8	8056	8115	8174	8233	8292	8350	8409	8468	8527	8586	59
9	8644	8703	8762	8821	8879	8938	8997	9056	9114	9173	59
740	869232	869290	869349	869408	869466	869525	869584	869642	869701	869760	59
1	9818	9877	9935	9994	870053	870111	870170	870228	870287	870345	59
2	870404	870462	870521	870579	0638	0696	0755	0813	0872	0930	58
3	0989	1047	1106	1164	1223	1281	1339	1398	1456	1515	58
4	1573	1631	1690	1748	1806	1865	1923	1981	2040	2098	58
5	2156	2215	2273	2331	2389	2448	2506	2564	2622	2681	58
6	2739	2797	2855	2913	2972	3030	3088	3146	3204	3262	58
7	3321	3379	3437	3495	3553	3611	3669	3727	3785	3844	58
8	3902	3960	4018	4076	4134	4192	4250	4308	4366	4424	58
9	4482	4540	4598	4656	4714	4772	4830	4888	4945	5003	58
750	875061	875119	875177	875235	875293	875351	875409	875466	875524	875582	58
1	5640	5698	5756	5813	5871	5929	5987	6045	6102	6160	58
2	6218	6276	6333	6391	6449	6507	6564	6622	6680	6737	58
3	6795	6853	6910	6968	7026	7083	7141	7199	7256	7314	58
4	7371	7429	7487	7544	7602	7659	7717	7774	7832	7889	58
5	7947	8004	8062	8119	8177	8234	8292	8349	8407	8464	57
6	8522	8579	8637	8694	8752	8809	8866	8924	8981	9039	57
7	9096	9153	9211	9268	9325	9383	9440	9497	9555	9612	57
8	9669	9726	9784	9841	9898	9956	880013	880070	880127	880185	57
9	880242	880299	880356	880413	880471	880528	0585	0642	0699	0756	57
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1	1385	1442	1499	1556	1613	1670	1727	1784	1841	1898	57
2	1955	2012	2069	2126	2183	2240	2297	2354	2411	2468	57
3	2525	2581	2638	2695	2752	2809	2866	2923	2980	3037	57
4	3093	3150	3207	3264	3321	3377	3434	3491	3548	3605	57
5	3661	3718	3775	3832	3888	3945	4002	4059	4115	4172	57
6	4229	4285	4342	4399	4455	4512	4569	4625	4682	4739	57
7	4795	4852	4909	4965	5022	5078	5135	5192	5248	5305	57
8	5361	5418	5474	5531	5587	5644	5700	5757	5813	5870	57
9	5926	5983	6039	6096	6152	6209	6265	6321	6378	6434	56
770	886491	886547	886604	886660	886716	886773	886829	886885	886942	886998	56
1	7054	7111	7167	7223	7280	7336	7392	7449	7505	7561	56
2	7617	7674	7730	7786	7842	7898	7955	8011	8067	8123	56
3	8179	8236	8292	8348	8404	8460	8516	8573	8629	8685	56
4	8741	8797	8853	8909	8965	9021	9077	9134	9190	9246	56
5	9302	9358	9414	9470	9526	9582	9638	9694	9750	9806	56
6	9862	9918	9974	890030	890086	890141	890197	890253	890309	890365	56
7	890421	890477	890533	0589	9645	0700	0756	0812	0868	0924	56
8	0980	1035	1091	1147	1203	1259	1314	1370	1426	1482	56
9	1537	1593	1649	1705	1760	1816	1872	1928	1983	2039	56
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1	2651	2707	2762	2818	2873	2929	2985	3040	3096	3151	56
2	3207	3262	3318	3373	3429	3484	3540	3595	3651	3706	56
3	3762	3817	3873	3928	3984	4039	4094	4150	4205	4261	55
4	4316	4371	4427	4482	4538	4593	4648	4704	4759	4814	55
5	4870	4925	4980	5036	5091	5146	5201	5257	5312	5367	55
6	5423	5478	5533	5588	5644	5699	5754	5809	5864	5920	55
7	5975	6030	6085	6140	6195	6251	6306	6361	6416	6471	55
8	6526	6581	6636	6692	6747	6802	6857	6912	6967	7022	55
9	7077	7132	7187	7242	7297	7352	7407	7462	7517	7572	55
790	897627	897682	897737	897792	897847	897902	897957	898012	898067	898122	55
1	8176	8231	8286	8341	8396	8451	8506	8561	8615	8670	55
2	8725	8780	8835	8890	8944	8999	9054	9109	9164	9218	55
3	9273	9328	9383	9437	9492	9547	9602	9656	9711	9766	55
4	9821	9875	9930	9985	900039	900094	900149	900203	900258	900312	55
5	900367	900422	900476	900531	0586	0640	0695	0749	0804	0859	55
6	0913	0968	1022	1077	1131	1186	1240	1295	1349	1404	55
7	1458	1513	1567	1622	1676	1731	1785	1840	1894	1948	54
8	2003	2057	2112	2166	2221	2275	2329	2384	2438	2492	54
9	2547	2601	2655	2710	2764	2818	2873	2927	2981	3036	54
800	903090	903144	903199	903253	903307	903361	903416	903470	903524	903578	54
1	3633	3687	3741	3795	3849	3904	3958	4012	4066	4120	54
2	4174	4229	4283	4337	4391	4445	4499	4553	4607	4661	54
3	4716	4770	4824	4878	4932	4986	5040	5094	5148	5202	54
4	5256	5310	5364	5418	5472	5526	5580	5634	5688	5742	54
5	5796	5850	5904	5958	6012	6066	6119	6173	6227	6281	54
6	6335	6389	6443	6497	6551	6604	6658	6712	6766	6820	54
7	6874	6927	6981	7035	7089	7143	7196	7250	7304	7358	54
8	7411	7465	7519	7573	7626	7680	7734	7787	7841	7895	54
9	7949	8002	8056	8110	8163	8217	8270	8324	8378	8431	54
810	908485	908539	908592	908646	908699	908753	908807	908860	908914	908967	54
1	9021	9074	9128	9181	9235	9289	9342	9396	9449	9503	54
2	9556	9610	9663	9716	9770	9823	9877	9930	9984	910037	53
3	910091	910144	910197	910251	910304	910358	910411	910464	910518	0571	53
4	0624	0678	0731	0784	0838	0891	0944	0998	1051	1104	53
5	1158	1211	1264	1317	1371	1424	1477	1530	1584	1637	53
6	1690	1743	1797	1850	1903	1956	2009	2063	2116	2169	53
7	2222	2275	2328	2381	2435	2488	2541	2594	2647	2700	53
8	2753	2806	2859	2913	2966	3019	3072	3125	3178	3231	53
9	3284	3337	3390	3443	3496	3549	3602	3655	3708	3761	53
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No.	0	1	2	3	4	5	6	7	8	9	Diff.
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1	4343	4396	4449	4502	4555	4608	4660	4713	4766	4819	53
2	4872	4925	4977	5030	5083	5136	5189	5241	5294	5347	53
3	5400	5453	5505	5558	5611	5664	5716	5769	5822	5875	53
4	5927	5980	6033	6085	6138	6191	6243	6296	6349	6401	53
5	6454	6507	6559	6612	6664	6717	6770	6822	6875	6927	53
6	6980	7033	7085	7138	7190	7243	7295	7348	7400	7453	53
7	7506	7558	7611	7663	7716	7768	7820	7873	7925	7978	52
8	8030	8083	8135	8188	8240	8293	8345	8397	8450	8502	52
9	8555	8607	8659	8712	8764	8816	8869	8921	8973	9026	52
830	919078	919130	919183	919235	919287	919340	919392	919444	919496	919549	52
1	9601	9653	9706	9758	9810	9862	9914	9967	920019	920071	52
2	920123	920176	920228	920280	920332	920384	920436	920489	0541	0593	52
3	0645	0697	0749	0801	0853	0906	0958	1010	1062	1114	52
4	1166	1218	1270	1322	1374	1426	1478	1530	1582	1634	52
5	1686	1738	1790	1842	1894	1946	1998	2050	2102	2154	52
6	2206	2258	2310	2362	2414	2466	2518	2570	2622	2674	52
7	2725	2777	2829	2881	2933	2985	3037	3089	3140	3192	52
8	3244	3296	3348	3399	3451	3503	3555	3607	3658	3710	52
9	3762	3814	3865	3917	3969	4021	4072	4124	4176	4228	52
840	924279	924331	924383	924434	924486	924538	924589	924641	924693	924744	52
1	4796	4848	4899	4951	5003	5054	5106	5157	5209	5261	52
2	5312	5364	5415	5467	5518	5570	5621	5673	5725	5776	52
3	5828	5879	5931	5982	6034	6085	6137	6188	6240	6291	51
4	6342	6394	6445	6497	6548	6600	6651	6702	6754	6805	51
5	6857	6908	6959	7011	7062	7114	7165	7216	7268	7319	51
6	7370	7422	7473	7524	7576	7627	7678	7730	7781	7832	51
7	7883	7935	7986	8037	8088	8140	8191	8242	8293	8345	51
8	8396	8447	8498	8549	8601	8652	8703	8754	8805	8857	51
9	8908	8959	9010	9061	9112	9163	9215	9266	9317	9368	51
850	929419	929470	929521	929572	929623	929674	929725	929776	929827	929879	51
1	9930	9981	930032	930083	930134	930185	930236	930287	930338	930389	51
2	930440	930491	0542	0592	0643	0694	0745	0796	0847	0898	51
3	0949	1000	1051	1102	1153	1204	1254	1305	1356	1407	51
4	1458	1509	1560	1610	1661	1712	1763	1814	1865	1915	51
5	1966	2017	2068	2118	2169	2220	2271	2322	2372	2423	51
6	2474	2524	2575	2626	2677	2727	2778	2829	2879	2930	51
7	2981	3031	3082	3133	3183	3234	3285	3335	3386	3437	51
8	3487	3538	3589	3639	3690	3740	3791	3841	3892	3943	51
9	3993	4044	4094	4145	4195	4246	4296	4347	4397	4448	51
860	934498	934549	934599	934650	934700	934751	934801	934852	934902	934953	50
1	5003	5054	5104	5154	5205	5255	5306	5356	5406	5457	50
2	5507	5558	5608	5658	5709	5759	5809	5860	5910	5960	50
3	6011	6061	6111	6162	6212	6262	6313	6363	6413	6463	50
4	6514	6564	6614	6665	6715	6765	6815	6865	6916	6966	50
5	7016	7066	7117	7167	7217	7267	7317	7367	7418	7468	50
6	7518	7568	7618	7668	7718	7769	7819	7869	7919	7969	50
7	8019	8069	8119	8169	8219	8269	8320	8370	8420	8470	50
8	8520	8570	8620	8670	8720	8770	8820	8870	8920	8970	50
9	9020	9070	9120	9170	9220	9270	9320	9369	9419	9469	50
870	939519	939569	939619	939669	939719	939769	939819	939869	939918	939968	50
1	940018	940068	940118	940168	940218	940267	940317	940367	940417	940467	50
2	0516	0566	0616	0666	0716	0765	0815	0865	0915	0964	50
3	1014	1064	1114	1163	1213	1263	1313	1362	1412	1462	50
4	1511	1561	1611	1660	1710	1760	1809	1859	1909	1958	50
5	2008	2058	2107	2157	2207	2256	2306	2355	2405	2455	50
6	2504	2554	2603	2653	2702	2752	2801	2851	2901	2950	50
7	3000	3049	3099	3148	3198	3247	3297	3346	3396	3445	49
8	3495	3544	3593	3643	3692	3742	3791	3841	3890	3939	49
9	3989	4038	4088	4137	4186	4236	4285	4335	4384	4433	49
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
880	944483	944532	944581	944631	944680	944729	944779	944828	944877	944927	49
1	4976	5025	5074	5124	5173	5222	5272	5321	5370	5419	49
2	5469	5518	5567	5616	5665	5715	5764	5813	5862	5912	49
3	5961	6010	6059	6108	6157	6207	6256	6305	6354	6403	49
4	6452	6501	6551	6600	6649	6698	6747	6796	6845	6894	49
5	6943	6992	7041	7090	7140	7189	7238	7287	7336	7385	49
6	7434	7483	7532	7581	7630	7679	7728	7777	7826	7875	49
7	7924	7973	8022	8070	8119	8168	8217	8266	8315	8364	49
8	8413	8462	8511	8560	8609	8657	8706	8755	8804	8853	49
9	8902	8951	8999	9048	9097	9146	9195	9244	9292	9341	49
890	949390	949439	949488	949536	949585	949634	949683	949731	949780	949829	49
1	9878	9926	9975	950024	950073	950121	950170	950219	950267	950316	49
2	950365	950414	950462	0511	0560	0608	0657	0706	0754	0803	49
3	0851	0900	0949	0997	1046	1095	1143	1192	1240	1289	49
4	1338	1386	1435	1483	1532	1580	1629	1677	1726	1775	49
5	1823	1872	1920	1969	2017	2066	2114	2163	2211	2260	48
6	2308	2356	2405	2453	2502	2550	2599	2647	2696	2744	48
7	2792	2841	2889	2938	2986	3034	3083	3131	3180	3228	48
8	3276	3325	3373	3421	3470	3518	3566	3615	3563	3711	48
9	3760	3808	3856	3905	3953	4001	4049	4098	4146	4194	48
900	954243	954291	954339	954387	954435	954484	954532	954580	954628	954677	48
1	4725	4773	4821	4869	4918	4966	5014	5062	5110	5158	48
2	5207	5255	5303	5351	5399	5447	5495	5543	5592	5640	48
3	56[illegible]	5736	5784	5832	5880	5928	5976	6024	6072	6120	48
4	6168	6216	6265	6313	6361	6409	6457	6505	6553	6601	48
5	6649	6697	6745	6793	6840	6888	6936	6984	7032	7080	48
6	7128	7176	7224	7272	7320	7368	7416	7464	7512	7559	48
7	7607	7655	7703	7751	7799	7847	7894	7942	7990	8038	48
8	8086	8134	8181	8229	8277	8325	8373	8421	8468	8516	48
9	8564	8612	8659	8707	8755	8803	8850	8898	8946	8994	48
910	959041	959089	959137	959185	959232	959280	959328	959375	959423	959471	48
1	9518	9566	9614	9661	9709	9757	9804	9852	9900	9947	48
2	9995	960042	960090	960138	960185	960233	960281	960328	960376	960423	48
3	960471	0518	0566	0613	0661	0709	0756	0804	0851	0899	48
4	0946	0994	1041	1089	1136	1184	1231	1279	1326	1374	48
5	1421	1469	1516	1563	1611	1658	1706	1753	1801	1848	47
6	1895	1943	1990	2038	2085	2132	2180	2227	2275	2322	47
7	2369	2417	2464	2511	2559	2606	2653	2701	2748	2795	47
8	2843	2890	2937	2985	3032	3079	3126	3174	3221	3268	47
9	3316	3363	3410	3457	3504	3552	3599	3646	3693	3741	47
920	963788	963835	963882	963929	963977	964024	964071	964118	964165	964212	47
1	4260	4307	4354	4401	4448	4495	4542	4590	4637	4684	47
2	4731	4778	4825	4872	4919	4966	5013	5061	5108	5155	47
3	5202	5249	5296	5343	5390	5437	5484	5531	5578	5625	47
4	5672	5719	5766	5813	5860	5907	5954	6001	6048	6095	47
5	6142	6189	6236	6283	6329	6376	6423	6470	6517	6564	47
6	6611	6658	6705	6752	6799	6845	6892	6939	6986	7033	47
7	7080	7127	7173	7220	7267	7314	7361	7408	7454	7501	47
8	7548	7595	7642	7688	7735	7782	7829	7875	7922	7969	47
9	8016	8062	8109	8156	8203	8249	8296	8343	8390	8436	47
930	968483	968530	968576	968623	968670	968716	968763	968810	968856	968903	47
1	8950	8996	9043	9090	9136	9183	9229	9276	9323	9369	47
2	9416	9463	9509	9556	9602	9649	9695	9742	9789	9835	47
3	9882	9928	9975	970021	970068	970114	970161	970207	970254	970300	47
4	970347	970393	970440	0486	0533	0579	0626	0672	0719	0765	46
5	0812	0858	0904	0951	0997	1044	1090	1137	1183	1229	46
6	1276	1322	1369	1415	1461	1508	1554	1601	1647	1693	46
7	1740	1786	1832	1879	1925	1971	2018	2064	2110	2157	46
8	2203	2249	2295	2342	2388	2434	2481	2527	2573	2619	46
9	2666	2712	2758	2804	2851	2897	2943	2989	3035	3082	46
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Dif
940	973128	973174	973220	973266	973313	973359	973405	973451	973497	973543	46
1	3590	3636	3682	3728	3774	3820	3866	3913	3959	4005	46
2	4051	4097	4143	4189	4235	4281	4327	4374	4420	4466	46
3	4512	4558	4604	4650	4696	4742	4788	4834	4880	4926	46
4	4972	5018	5064	5110	5156	5202	5248	5294	5340	5386	46
5	5432	5478	5524	5570	5616	5662	5707	5753	5799	5845	46
6	5891	5937	5983	6029	6075	6121	6167	6212	6258	6304	46
7	6350	6396	6442	6488	6533	6579	6625	6671	6717	6763	46
8	6808	6854	6900	6946	6992	7037	7083	7129	7175	7220	46
9	7266	7312	7358	7403	7449	7495	7541	7586	7632	7678	46
950	977724	977769	977815	977861	977906	977952	977998	978043	978089	978135	46
1	8181	8226	8272	8317	8363	8409	8454	8500	8546	8591	46
2	8637	8683	8728	8774	8819	8865	8911	8956	9002	9047	46
3	9093	9138	9184	9230	9275	9321	9366	9412	9457	9503	46
4	9548	9594	9639	9685	9730	9776	9821	9867	9912	9958	46
5	980003	980049	980094	980140	980185	980231	980276	980322	980367	980412	45
6	0458	0503	0549	0594	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
960	[illegible]	[illegible]	982362	982407	982452	982497	982543	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	2814	2859	2904	2949	2994	3040	3085	3130	45
2	[illegible]	[illegible]	3265	3310	3356	3401	3446	3491	3536	3581	45
3	[illegible]	3671	3716	3762	3807	3852	3897	3942	3987	4032	45
4	4077	4122	4167	4212	4257	4302	4347	4392	4437	4482	45
5	4527	4572	4617	4662	4707	4752	4797	4842	4887	4932	45
6	4977	5022	5067	5112	5157	5202	5247	5292	5337	5382	45
7	5426	5471	5516	5561	5606	5651	5696	5741	5786	5830	45
8	5875	5920	5965	6010	6055	6100	6144	6189	6234	6279	45
9	6324	6369	6413	6458	6503	6548	6593	6637	6682	6727	45
970	986772	986817	986861	986906	986951	986996	987040	987085	987130	987175	45
1	7219	7264	7309	7353	7398	7443	7488	7532	7577	7622	45
2	7666	7711	7756	7800	7845	7890	7934	7979	8024	8068	45
3	8113	8157	8202	8247	8291	8336	8381	8425	8470	8514	45
4	8559	8604	8648	8693	8737	8782	8826	8871	8916	8960	45
5	9005	9049	9094	9138	9183	9227	9272	9316	9361	9405	45
6	9450	9494	9539	9583	9628	9672	9717	9761	9806	9850	44
7	9895	9939	9983	990028	990072	990117	990161	990206	990250	990294	44
8	990339	990383	990428	0472	0516	0561	0605	0650	0694	0738	44
9	0783	0827	0871	0916	0960	1004	1049	1093	1137	1182	44
980	991226	991270	991315	991359	991403	991448	991492	991536	991580	991625	44
1	1669	1713	1758	1802	1846	1890	1935	1979	2023	2067	44
2	2111	2156	2200	2244	2288	2333	2377	2421	2465	2509	44
3	2554	2598	2642	2686	2730	2774	2819	2863	2907	2951	44
4	2995	3039	3083	3127	3172	3216	3260	3304	3348	3392	44
5	3436	3480	3524	3568	3613	3657	3701	3745	3789	3833	44
6	3877	3921	3965	4009	4053	4097	4141	4185	4229	4273	44
7	4317	4361	4405	4449	4493	4537	4581	4625	4669	4713	44
8	4757	4801	4845	4889	4933	4977	5021	5065	5108	5152	44
9	5196	5240	5284	5328	5372	5416	5460	5504	5547	5591	44
990	995635	995679	995723	995767	995811	995854	995898	995942	995986	996030	44
1	6074	6117	6161	6205	6249	6293	6337	6380	6424	6468	44
2	6512	6555	6599	6643	6687	6731	6774	6818	6862	6906	44
3	6949	6993	7037	7080	7124	7168	7212	7255	7299	7343	44
4	7386	7430	7474	7517	7561	7605	7648	7692	7736	7779	44
5	7823	7867	7910	7954	7998	8041	8085	8129	8172	8216	44
6	8259	8303	8347	8390	8434	8477	8521	8564	8608	8652	44
7	8695	8739	8782	8826	8869	8913	8956	9000	9043	9087	44
8	9131	9174	9218	9261	9305	9348	9392	9435	9479	9522	44
9	9565	9609	9652	9696	9739	9783	9826	9870	9913	9957	43
No.	0	1	2	3	4	5	6	7	8	9	Dif

TABLE XIII.

LOGARITHMIC SINES, COSINES, TANGENTS, AND COTANGENTS.

N. B.—THE minutes in the left-hand column of each page, increasing downwards, belong to the degrees at the top; and those increasing upwards, in the right-hand column, belong to the degrees below.

In using the differences for one second, in columns D, the two right-hand figures should be marked off as decimals. Thus the difference for log. sin. 1° 12′ 5″ would be 99.82 × 5 = 499.1, additive to the mantissa .321027 treated as an integer, and the difference for log. cos. 8° 30′ 50″ would be 0.30 × 50 = 16.0 subtractive from the mantissa .995203 treated as an integer.

The differences in columns D range opposite the upper one of the two functions to which they respectively apply.

The first column D refers to Sines, the second to Cosines, the third to both Tangents and Cotangents.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	Inf. Neg.		10·000000		0·000000		Infinite.	60
1	6·463726	501717	000000	00	6·463726	501717	13·536274	59
2	764756	293485	000000	00	764756	293485	235244	58
3	940847	208231	000000	00	940847	208231	059153	57
4	7·065786	161517	000000	00	7·065786	161517	12·934214	56
5	162696	131968	000000	00	162696	131969	837304	55
6	241877	111578	9·999999	01	241878	111578	758122	54
7	308824	96653	999999	01	308825	99653	691175	53
8	366816	85254	999999	01	366817	85254	633183	52
9	417968	76263	999999	01	417970	76263	582030	51
10	463725	68988	999998	01	463727	68988	536273	50
11	7·505118	62981	9·999998	01	7·505120	62981	12·494880	49
12	542906	57936	999997	01	542909	57938	457091	48
13	577668	53641	999997	01	577672	53642	422328	47
14	609853	49938	999996	01	609857	49939	390143	46
15	639816	46714	999996	01	639820	46715	360180	45
16	667845	43881	999995	01	667849	43882	332151	44
17	694173	41372	999995	01	694179	41373	305821	43
18	718997	39135	999994	01	719003	39136	280997	42
19	742477	37127	999993	01	742484	37128	257516	41
20	764754	35315	999993	01	764761	35317	235239	40
21	7·785943	33672	9·999992	01	7·785951	33673	12·214049	39
22	806146	32175	999991	01	806155	32176	193845	38
23	825451	30805	999990	01	825460	30806	174540	37
24	843934	29547	999989	02	843944	29549	156056	36
25	861662	28388	999988	02	861674	28390	138326	35
26	878695	27317	999988	02	878708	27318	121292	34
27	895085	26323	999987	02	895099	26325	104901	33
28	910879	25399	999986	02	910894	25401	089106	32
29	926119	24538	999985	02	926134	24540	073866	31
30	940842	23733	999983	02	940858	23735	059142	30
31	7·955082	22980	9·999982	02	7·955100	22981	12·044900	29
32	968870	22273	999981	02	968889	22275	031111	28
33	982233	21608	999980	02	982253	21610	017747	27
34	995198	20981	999979	02	995219	20983	004781	26
35	8·007787	20390	999977	02	8·007809	20392	11·992191	25
36	020021	19831	999976	02	020045	19833	979955	24
37	031919	19302	999975	02	031945	19305	968055	23
38	043501	18801	999973	02	043527	18803	956473	22
39	054781	18325	999972	02	054809	18327	945191	21
40	065776	17872	999971	02	065806	17874	934194	20
41	8·076500	17441	9·999969	02	8·076531	17444	11·923469	19
42	086965	17031	999968	02	086997	17034	913003	18
43	097183	16639	999966	02	097217	16642	902783	17
44	107167	16265	999964	03	107202	16268	892797	16
45	116926	15908	999963	03	116963	15910	883037	15
46	126471	15566	999961	03	126510	15568	873490	14
47	135810	15238	999959	03	135851	15241	864149	13
48	144953	14924	999958	03	144996	14927	855004	12
49	153907	14622	999956	03	153952	14627	846048	11
50	162681	14333	999954	03	162727	14336	837273	10
51	8·171280	14054	9·999952	03	8·171328	14057	11·828672	9
52	179713	13786	999950	03	179763	13790	820237	8
53	187985	13529	999948	03	188036	13532	811964	7
54	196102	13280	999946	03	196156	13284	803844	6
55	204070	13041	999944	03	204126	13044	795874	5
56	211895	12810	999942	04	211953	12814	788047	4
57	219581	12587	999940	04	219641	12590	780359	3
58	227134	12372	999938	04	227195	12376	772805	2
59	234557	12164	999936	04	234621	12168	765379	1
60	241855	11963	999934	04	241921	11967	758079	0
	Cosine		Sine		Cotang.		Tang.	M.

89 Degrees

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·241855	11963	9·999934	04	8·241921	11967	11·758079	60
1	249033	11768	999932	04	249102	11772	750898	59
2	256094	11580	999929	04	256165	11584	743835	58
3	263042	11398	999927	04	263115	11402	736885	57
4	269881	11221	999925	04	269956	11225	730044	56
5	276614	11050	999922	04	276691	11054	723309	55
6	283243	10883	999920	04	283323	10887	716677	54
7	289773	10721	999918	04	289856	10726	710144	53
8	296207	10565	999915	04	296292	10570	703708	52
9	302546	10413	999913	04	302634	10418	697366	51
10	308794	10266	999910	04	308884	10270	691116	50
11	8·314954	10122	9·999907	04	8·315046	10126	11·684954	49
12	321027	9982	999905	04	321122	9987	678878	48
13	327016	9847	999902	04	327114	9851	672886	47
14	332924	9714	999899	05	333025	9719	666975	46
15	338753	9586	999897	05	338856	9590	661144	45
16	344504	9460	999894	05	344610	9465	655390	44
17	350181	9338	999891	05	350289	9343	649711	43
18	355783	9219	999888	05	355895	9224	644105	42
19	361315	9103	999885	05	361430	9108	638570	41
20	366777	8990	999882	05	366895	8995	633105	40
21	8·372171	8880	9·999879	05	8·372292	8885	11·627708	39
22	377499	8772	999876	05	377622	8777	622378	38
23	382762	8667	999873	05	382889	8672	617111	37
24	387962	8564	999870	05	388092	8570	611908	36
25	393101	8464	999867	05	393234	8470	606766	35
26	398179	8366	999864	05	398315	8371	601685	34
27	403199	8271	999861	05	403338	8276	596662	33
28	408161	8177	999858	05	408304	8182	591696	32
29	413068	8086	999854	05	413213	8091	586787	31
30	417919	7996	999851	06	418068	8002	581932	30
31	8·422717	7909	9·999848	06	8·422869	7914	11·577131	29
32	427462	7823	999844	06	427618	7830	572382	28
33	432156	7740	999841	06	432315	7745	567685	27
34	436800	7657	999838	06	436962	7663	563038	26
35	441394	7577	999834	06	441560	7583	558440	25
36	445941	7499	999831	06	446110	7505	553890	24
37	450440	7422	999827	06	450613	7428	549387	23
38	454893	7346	999823	06	455070	7352	544930	22
39	459301	7273	999820	06	459481	7279	540519	21
40	463665	7200	999816	06	463849	7206	536151	20
41	8·467985	7129	9·999812	06	8·468172	7135	11·531828	19
42	472263	7060	999809	06	472454	7066	527546	18
43	476498	6991	999805	06	476693	6998	523307	17
44	480693	6924	999801	06	480892	6931	519108	16
45	484848	6859	999797	07	485050	6865	514950	15
46	488963	6794	999793	07	489170	6801	510830	14
47	493040	6731	999790	07	493250	6738	506750	13
48	497078	6669	999786	07	497293	6676	502707	12
49	501080	6608	999782	07	501298	6615	498702	11
50	505045	6548	999778	07	505267	6555	494733	10
51	8·508974	6489	9·999774	07	8·509200	6496	11·490800	9
52	512867	6431	999769	07	513098	6439	486902	8
53	516726	6375	999765	07	516961	6382	483039	7
54	520551	6319	999761	07	520790	6326	479210	6
55	524343	6264	999757	07	524586	6272	475414	5
56	528102	6211	989753	07	528349	6218	471651	4
57	531828	6158	999748	07	532080	6165	467920	3
58	535523	6106	999744	07	535779	6113	464221	2
59	539186	6055	999740	07	539447	6062	460553	1
60	542819	6004	999735	07	543084	6012	456916	0
	Cosine		Sine		Cotang.		Tang.	M.

88 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·542819	6004	9·999735	07	8·543084	6012	11·456916	60
1	546422	5955	999731	07	546691	5962	453309	59
2	549995	5906	999726	07	550268	5914	449732	58
3	553539	5858	999722	08	553817	5866	446183	57
4	557054	5811	999717	08	557336	5819	442664	56
5	560540	5765	999713	08	560828	5773	439172	55
6	563999	5719	999708	08	564291	5727	435709	54
7	567431	5674	999704	08	567727	5682	432273	53
8	570836	5630	999699	08	571137	5638	428863	52
9	574214	5587	999694	08	574520	5595	425480	51
10	577566	5544	999689	08	577877	5552	422123	50
11	8·580892	5502	9·999685	08	8·581208	5510	11·418792	49
12	584193	5460	999680	08	584514	5468	415486	48
13	587469	5419	999675	08	587795	5427	412205	47
14	590721	5379	999670	08	591051	5387	408949	46
15	593948	5339	999665	08	594283	5347	405717	45
16	597152	5300	999660	08	597492	5308	402508	44
17	600332	5261	999655	08	600677	5270	399323	43
18	603489	5223	999650	08	603839	5232	396161	42
19	606623	5186	999645	09	606978	5194	393022	41
20	609734	5149	999640	09	610094	5158	389906	40
21	8·612823	5112	9·999635	09	8·613189	5121	11·386811	39
22	615891	5076	999629	09	616262	5085	383738	38
23	618937	5041	999624	09	619313	5050	380687	37
24	621962	5006	999619	09	622343	5015	377657	36
25	624965	4972	999614	09	625352	4981	374648	35
26	627948	4938	999608	09	628340	4947	371660	34
27	630911	4904	999603	09	631308	4913	368692	33
28	633854	4871	999597	09	634256	4880	365744	32
29	636776	4839	999592	09	637184	4848	362816	31
30	639680	4806	999586	09	640093	4816	359907	30
31	8·642563	4775	9·999581	09	8·642982	4784	11·357018	29
32	645428	4743	999575	09	645853	4753	354147	28
33	648274	4712	999570	09	648704	4722	351296	27
34	651102	4682	999564	09	651537	4691	348463	26
35	653911	4652	999558	10	654352	4661	345648	25
36	656702	4622	999553	10	657149	4631	342851	24
37	659475	4592	999547	10	659928	4602	340072	23
38	662230	4563	999541	10	662689	4573	337311	22
39	664968	4535	999535	10	665433	4544	334567	21
40	667689	4506	999529	10	668160	4526	331840	20
41	8·670393	4479	9·999524	10	8·670870	4488	11·329130	19
42	673080	4451	999518	10	673563	4461	326437	18
43	675751	4424	999512	10	676239	4434	323761	17
44	678405	4397	999506	10	678900	4417	321100	16
45	681043	4370	999500	10	681544	4380	318456	15
46	683665	4344	999493	10	684172	4354	315828	14
47	686272	4318	999487	10	686784	4328	313216	13
48	688863	4292	999481	10	689381	4303	310619	12
49	691438	4267	999475	10	691963	4277	308037	11
50	693998	4242	999469	10	694529	4252	305471	10
51	8·696543	4217	9·999463	11	8·697081	4228	11·302919	9
52	699073	4192	999456	11	699617	4203	300383	8
53	701589	4168	999450	11	702139	4179	297861	7
54	704090	4144	999443	11	704646	4155	295354	6
55	706577	4121	999437	11	707140	4132	292860	5
56	709049	4097	999431	11	709618	4108	290382	4
57	711507	4074	999424	11	712083	4085	287917	3
58	713952	4051	999418	11	714534	4062	285465	2
59	716383	4029	999411	11	716972	4040	283028	1
60	718800	4006	999404	11	719396	4017	280604	0
	Cosine		Sine		Cotang.		Tang.	M.

87 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·718800	4006	9·999404	11	8·719396	4017	11·280604	60
1	721204	3984	999398	11	721806	3995	278194	59
2	723595	3962	999391	11	724204	3974	275796	58
3	725972	3941	999384	11	726588	3952	273412	57
4	728337	3919	999378	11	728959	3930	271041	56
5	730688	3898	999371	11	731317	3909	268683	55
6	733027	3877	999364	12	733663	3889	266337	54
7	735354	3857	999357	12	735996	3868	264004	53
8	737667	3836	999350	12	738317	3848	261683	52
9	739969	3816	999343	12	740626	3827	259374	51
10	742259	3796	999336	12	742922	3807	257078	50
11	8·744536	3776	9·999329	12	8·745207	3787	11·254793	49
12	746802	3756	999322	12	747479	3768	252521	48
13	749055	3737	999315	12	749740	3749	250260	47
14	751297	3717	999308	12	751989	3729	248011	46
15	753528	3698	999301	12	754227	3710	245773	45
16	755747	3679	999294	12	756453	3692	243547	44
17	757955	3661	999286	12	758668	3673	241332	43
18	760151	3642	999279	12	760872	3655	239128	42
19	762337	3624	999272	12	763065	3636	236935	41
20	764511	3606	999265	12	765246	3618	234754	40
21	8·766675	3588	9·999257	12	8·767417	3600	11·232583	39
22	768828	3570	999250	13	769578	3583	230422	38
23	770970	3553	999242	13	771727	3565	228273	37
24	773101	3535	999235	13	773866	3548	226134	36
25	775223	3518	999227	13	775995	3531	224005	35
26	777333	3501	999220	13	778114	3514	221886	34
27	779434	3484	999212	13	780222	3497	219778	33
28	781524	3467	999205	13	782320	3480	217680	32
29	783605	3451	999197	13	784408	3464	215592	31
30	785675	3431	999189	13	786486	3447	213514	30
31	8·787736	3418	9·999181	13	8·788554	3431	11·211446	29
32	789787	3402	999174	13	790613	3414	209387	28
33	791828	3386	999166	13	792662	3399	207338	27
34	793859	3370	999158	13	794701	3383	205299	26
35	795881	3354	999150	13	796731	3368	203269	25
36	797894	3339	999142	13	798752	3352	201248	24
37	799897	3323	999134	13	800763	3337	199237	23
38	801892	3308	999126	13	802765	3322	197235	22
39	803876	3293	999118	13	804758	3307	195242	21
40	805852	3278	999110	13	806742	3292	193258	20
41	8·807819	3263	9·999102	13	8·808717	3278	11·191283	19
42	809777	3249	999094	14	810683	3262	189317	18
43	811726	3234	999086	14	812641	3248	187359	17
44	813667	3219	999077	14	814589	3233	185411	16
45	815599	3205	999069	14	816529	3219	183471	15
46	817522	3191	999061	14	818461	3205	181539	14
47	819436	3177	999053	14	820384	3191	179616	13
48	821343	3163	999044	14	822298	3177	177702	12
49	823240	3149	999036	14	824205	3163	175795	11
50	825130	3135	999027	14	826103	3150	173897	10
51	8·827011	3122	9·999019	14	8·827992	3136	11·172008	9
52	828884	3108	999010	14	829874	3123	170126	8
53	830749	3095	999002	14	831748	3110	168252	7
54	832607	3082	998993	14	833613	3096	166387	6
55	834456	3069	998984	14	835471	3083	164529	5
56	836297	3056	998976	14	837321	3070	162679	4
57	838130	3043	998967	15	839163	3057	160837	3
58	839956	3030	998958	15	840998	3045	159002	2
59	841774	3017	998950	15	842825	3032	157175	1
60	843585	3000	998941	15	844644	3019	155356	0
	Cosine		Sine		Cotang.		Tang.	

Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·843585	3005	9·998941	15	8·844644	3019	11·155356	60
1	845387	2992	998932	15	846455	3007	153545	59
2	847183	2980	998923	15	848260	2995	151740	58
3	848971	2967	998914	15	850057	2982	149943	57
4	850751	2955	998905	15	851846	2970	148154	56
5	852525	2943	998896	15	853628	2958	146372	55
6	854291	2931	998887	15	855403	2946	144597	54
7	856049	2919	998878	15	857171	2935	142829	53
8	857801	2907	998869	15	858932	2923	141068	52
9	859546	2896	998860	15	860686	2911	139314	51
10	861283	2884	998851	15	862433	2900	137567	50
11	8·863014	2873	9·998841	15	8·864173	2888	11·135827	49
12	864738	2861	998832	15	865906	2877	134094	48
13	866455	2850	998823	16	867632	2866	132368	47
14	868165	2839	998813	16	869351	2854	130649	46
15	869868	2828	998804	16	871064	2843	128936	45
16	871565	2817	998795	16	872770	2832	127230	44
17	873255	2806	998785	16	874469	2821	125531	43
18	874938	2795	998776	16	876162	2811	123838	42
19	876615	2786	998766	16	877849	2800	122151	41
20	878285	2773	998757	16	879529	2789	120471	40
21	8·879949	2763	9·998747	16	8·881202	2779	11·118798	39
22	881607	2752	998738	16	882869	2768	117131	38
23	883258	2742	998728	16	884530	2758	115470	37
24	884903	2731	998718	16	886185	2747	113815	36
25	886542	2721	998708	16	887833	2737	112167	35
26	888174	2711	998699	16	889476	2727	110524	34
27	889801	2700	998689	16	891112	2717	108888	33
28	891421	2690	998679	16	892742	2707	107258	32
29	893035	2680	998669	17	894366	2697	105634	31
30	894643	2670	998659	17	895984	2687	104016	30
31	8·896246	2660	9·998649	17	8·897596	2677	11·102404	29
32	897842	2651	998639	17	899203	2667	100797	28
33	899432	2641	998629	17	900803	2658	099197	27
34	901017	2631	998619	17	902398	2648	097602	26
35	902596	2622	998609	17	903987	2638	096013	25
36	904169	2612	998599	17	905570	2629	094430	24
37	905736	2603	998589	17	907147	2620	092853	23
38	907297	2593	998578	17	908719	2610	091281	22
39	908853	2584	998568	17	910285	2601	089715	21
40	910404	2575	998558	17	911846	2592	088154	20
41	8·911949	2566	9·998548	17	8·913401	2583	11·086599	19
42	913488	2556	998537	17	914951	2574	085049	18
43	915022	2547	998527	17	916495	2565	083505	17
44	916550	2538	998516	18	918034	2556	081966	16
45	918073	2529	998506	18	919568	2547	080432	15
46	919591	2520	998495	18	921096	2538	078904	14
47	921103	2512	998485	18	922619	2530	077381	13
48	922610	2503	998474	18	924136	2521	075864	12
49	924112	2494	998464	18	925649	2512	074351	11
50	925609	2486	998453	18	927156	2503	072844	10
51	8·927100	2477	9·998442	18	8·928658	2495	11·071342	9
52	928587	2469	998431	18	930155	2486	069845	8
53	930068	2460	998421	18	931647	2478	068353	7
54	931544	2452	998410	18	933134	2470	066866	6
55	933015	2443	998399	18	934616	2461	065384	5
56	934481	2435	998388	18	936093	2453	063907	4
57	935942	2427	998377	18	937565	2445	062435	3
58	937398	2419	998366	18	939032	2437	060968	2
59	938850	2411	998355	18	940494	2430	059506	1
60	940296	2403	998344	18	941952	2421	058048	0
	Cosine		Sine		Cotang.		Tang.	M.

85 Degrees

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·940296	2403	9·998344	19	8·941952	2421	11·058048	60
1	941738	2394	998333	19	943404	2413	056596	59
2	943174	2387	998322	19	944852	2405	055148	58
3	944606	2379	998311	19	946295	2397	053705	57
4	946034	2371	998300	19	947734	2390	052266	56
5	947456	2363	998289	19	949168	2382	050832	55
6	948874	2355	998277	19	950597	2374	049403	54
7	950287	2348	998266	19	952021	2366	047979	53
8	951696	2340	998255	19	953441	2360	046559	52
9	953100	2332	998243	19	954856	2351	045144	51
10	954499	2325	998232	19	956267	2344	043733	50
11	8·955894	2317	9·998220	19	8·957674	2337	11·042326	49
12	957284	2310	998209	19	959075	2329	040925	48
13	958670	2302	998197	19	960473	2323	039527	47
14	960052	2295	998186	19	961866	2314	038134	46
15	961429	2288	998174	19	963255	2307	036745	45
16	962801	2280	998163	19	964639	2300	035361	44
17	964170	2273	998151	19	966019	2293	033981	43
18	965534	2266	998139	20	967394	2286	032606	42
19	966893	2259	998128	20	968766	2279	031234	41
20	968249	2252	998116	20	970133	2271	029867	40
21	8·969600	2244	9·998104	20	8·971496	2265	11·028504	39
22	970947	2238	998092	20	972855	2257	027145	38
23	972289	2231	998080	20	974209	2251	025791	37
24	973628	2224	998068	20	975560	2244	024440	36
25	974962	2217	998056	20	976906	2237	023094	35
26	976293	2210	998044	20	978248	2230	021752	34
27	977619	2203	998032	20	979586	2223	020414	33
28	978941	2197	998020	20	980921	2217	019079	32
29	980259	2190	998008	20	982251	2210	017749	31
30	981573	2183	997996	20	983577	2204	016423	30
31	8·982883	2177	9·997984	20	8·984899	2197	11·015101	29
32	984189	2170	997972	20	986217	2191	013783	28
33	985491	2163	997959	20	987532	2184	012468	27
34	986789	2157	997947	20	988842	2178	011158	26
35	988083	2150	997935	21	990149	2171	009851	25
36	989374	2144	997922	21	991451	2165	008549	24
37	990660	2138	997910	21	992750	2158	007250	23
38	991943	2131	997897	21	994045	2152	005955	22
39	993222	2125	997885	21	995337	2146	004663	21
40	994497	2119	997872	21	996624	2140	003376	20
41	8·995768	2112	9·997860	21	8·997908	2134	11·002092	19
42	997036	2106	997847	21	999188	2127	000812	18
43	998299	2100	997835	21	9·000465	2121	10·999535	17
44	999560	2094	997822	21	001738	2115	998262	16
45	9·000816	2087	997809	21	003007	2109	996993	15
46	002069	2082	997797	21	004272	2103	995728	14
47	003318	2076	997784	21	005534	2097	994466	13
48	004563	2070	997771	21	006792	2091	993208	12
49	005805	2064	997758	21	008047	2085	991953	11
50	007044	2058	997745	21	009298	2080	990702	10
51	9·008278	2052	9·997732	21	9·010546	2074	10·989454	9
52	009510	2046	997719	21	011790	2068	988210	8
53	010737	2040	997706	21	013031	2062	986969	7
54	011962	2034	997693	22	014268	2056	985732	6
55	013182	2029	997680	22	015502	2051	984498	5
56	014400	2023	997667	22	016732	2045	983268	4
57	015613	2017	997654	22	017959	2040	982041	3
58	016824	2012	997641	22	019183	2033	980817	2
59	018031	2006	997628	22	020403	2028	979597	1
60	019235	2000	997614	22	021620	2023	978380	0
	Cosine		Sine		Cotang.		Tang.	M.

Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·019235	2000	9·997614	22	9·021620	2023	10·978380	60
1	020435	1995	997601	22	022834	2017	977166	59
2	021632	1989	997588	22	024044	2011	975956	58
3	022825	1984	997574	22	025251	2006	974749	57
4	024016	1978	997561	22	026455	2000	973545	56
5	025203	1973	997547	22	027655	1995	972345	55
6	026386	1967	997534	23	028852	1990	971148	54
7	027567	1962	997520	23	030046	1985	969954	53
8	028744	1957	997507	23	031237	1979	968763	52
9	029918	1951	997493	23	032425	1974	967575	51
10	031089	1947	997480	23	033609	1969	966391	50
11	9·032257	1941	9·997466	23	9·034791	1964	10·965209	49
12	033421	1936	997452	23	035969	1958	964031	48
13	034582	1930	997439	23	037144	1953	962856	47
14	035741	1925	997425	23	038316	1948	961684	46
15	036896	1920	997411	23	039485	1943	960515	45
16	038048	1915	997397	23	040651	1938	959349	44
17	039197	1910	997383	23	041813	1933	958187	43
18	040342	1905	997369	23	042973	1928	957027	42
19	041485	1899	997355	23	044130	1923	955870	41
20	042625	1894	997341	23	045284	1918	954716	40
21	9 043762	1889	9·997327	24	9·046434	1913	10·953566	39
22	044895	1884	997313	24	047582	1908	952418	38
23	046026	1879	997299	24	048727	1903	951273	37
24	047154	1875	997285	24	049869	1898	950131	36
25	048279	1870	997271	24	051008	1893	948992	35
26	049400	1865	997257	24	052144	1889	947856	34
27	050519	1860	997242	24	053277	1884	946723	33
28	051635	1855	997228	24	054407	187[illegible]	945593	32
29	052749	1850	997214	24	055535	1874	944465	31
30	053859	1845	997199	24	056659	1870	943341	30
31	054966	1841	9·997185	24	9·057781	1865	10·942219	29
32	056071	1836	997170	24	058900	1869	941100	28
33	057172	1831	997156	24	060016	1855	939984	27
34	058271	1827	997141	24	061130	1851	938870	26
35	059367	1822	997127	24	062240	1846	937760	25
36	060460	1817	997112	24	063348	1842	936652	24
37	061551	1813	997098	24	064453	1837	935547	23
38	062639	1808	997083	25	065556	1833	934444	22
39	063724	1804	997068	25	066655	1828	833345	21
40	064806	1799	997053	25	067752	1824	932248	20
41	9·065885	1794	9·997039	25	9·068846	1819	10·931154	19
42	066962	1790	997024	25	069938	1815	930062	18
43	068036	1786	997009	25	071027	1810	928973	17
44	069107	1781	996994	25	072113	1806	927887	16
45	070176	1777	996979	25	073197	1802	926803	15
46	071242	1772	996964	25	074278	1797	925722	14
47	072306	1768	996949	25	075356	1793	924644	13
48	073366	1763	996934	25	076432	1789	923568	12
49	074424	1759	996919	25	077505	1784	922495	11
50	075480	1755	996904	25	078576	1780	921424	10
51	9·076533	1750	9·996889	25	9·079644	1776	10·920356	9
52	077583	1746	996874	25	080710	1772	919290	8
53	078631	1742	996858	25	081773	1767	918227	7
54	079676	1738	996843	25	082833	1763	917167	6
55	080719	1733	996828	25	083891	1759	916109	5
56	081759	1729	996812	26	084947	1755	915053	4
57	082797	1725	996797	26	086000	1751	914000	3
58	083832	1721	996782	26	087050	1747	912950	2
59	084864	1717	996766	26	088098	1743	911902	1
60	085894	1713	996751	26	089144	1738	910856	0
	Cosine		Sine		Cotang.		Tang.	M.

83 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·019235	2000	9·997614	22	9·021620	2023	10·978380	60
1	020435	1995	997601	22	022834	2017	977166	59
2	021632	1989	997588	22	024044	2011	975956	58
3	022825	1984	997574	22	025251	2006	974749	57
4	024016	1978	997561	22	026455	2000	973545	56
5	025203	1973	997547	22	027655	1995	972345	55
6	026386	1967	997534	23	028852	1990	971148	54
7	027567	1962	997520	23	030046	1985	969954	53
8	028744	1957	997507	23	031237	1979	968763	52
9	029918	1951	997493	23	032425	1974	967575	51
10	031089	1947	997480	23	033609	1969	966391	50
11	9·032257	1941	9·997466	23	9·034791	1964	10·965209	49
12	033421	1936	997452	23	035969	1958	964031	48
13	034582	1930	997439	23	037144	1953	962856	47
14	035741	1925	997425	23	038316	1948	961684	46
15	036896	1920	997411	23	039485	1943	960515	45
16	038048	1915	997397	23	040651	1938	959349	44
17	039197	1910	997383	23	041813	1933	958187	43
18	040342	1905	997369	23	042973	1928	957027	42
19	041485	1899	997355	23	044130	1923	955870	41
20	042625	1894	997341	23	045284	1918	954716	40
21	9·043762	1889	9·997327	24	9·046434	1913	10·953566	39
22	044895	1884	997313	24	047582	1908	952418	38
23	046026	1879	997299	24	048727	1903	951273	37
24	047154	1875	997285	24	049869	1898	950131	36
25	048279	1870	997271	24	051008	1893	948992	35
26	049400	1865	997257	24	052144	1889	947856	34
27	050519	1860	997242	24	053277	1884	946723	33
28	051635	1855	997228	24	054407	187[illegible]	945593	32
29	052749	1850	997214	24	055535	1874	944465	31
30	053859	1845	997199	24	056659	1870	943341	30
31	054966	1841	9·997185	24	9·057781	1865	10·942219	29
32	056071	1836	997170	24	058900	1869	941100	28
33	057172	1831	997156	24	060016	1855	939984	27
34	058271	1827	997141	24	061130	1851	938870	26
35	059367	1822	997127	24	062240	1846	937760	25
36	060460	1817	997112	24	063348	1842	936652	24
37	061551	1813	997098	24	064453	1837	935547	23
38	062639	1808	997083	25	065556	1833	934444	22
39	063724	1804	997068	25	066655	1828	833345	21
40	064806	1799	997053	25	067752	1824	932248	20
41	9·065885	1794	9·997039	25	9·068846	1819	10·931154	19
42	066962	1790	997024	25	069938	1815	930062	18
43	068036	1786	997009	25	071027	1810	928973	17
44	069107	1781	996994	25	072113	1806	927887	16
45	070176	1777	996979	25	073197	1802	926803	15
46	071242	1772	996964	25	074278	1797	925722	14
47	072306	1768	996949	25	075356	1793	924644	13
48	073366	1763	996934	25	076432	1789	923568	12
49	074424	1759	996919	25	077505	1784	922495	11
50	075480	1755	996904	25	078576	1780	921424	10
51	9·076533	1750	9·996889	25	9·079644	1776	10·920356	9
52	077583	1746	996874	25	080710	1772	919290	8
53	078631	1742	996858	25	081773	1767	918227	7
54	079676	1738	996843	25	082833	1763	917167	6
55	080719	1733	996828	25	083891	1759	916109	5
56	081759	1729	996812	26	084947	1755	915053	4
57	082797	1725	996797	26	086000	1751	914000	3
58	083832	1721	996782	26	087050	1747	912950	2
59	084864	1717	996766	26	088098	1743	911902	1
60	085894	1713	996751	26	089144	1738	910856	0
	Cosine		Sine		Cotang.		Tang.	M.

83 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang	
0	9·085894	1713	9·996751	26	9·089144	1738	10·910856	60
1	086922	1709	996735	26	090187	1734	909813	59
2	087947	1704	996720	26	091228	1730	908772	58
3	088970	1700	996704	26	092266	1727	907734	57
4	089990	1696	996688	26	093302	1722	906698	56
5	091008	1692	996673	26	094336	1719	905664	55
6	092024	1688	996657	26	095367	1715	904633	54
7	093037	1684	996641	26	096395	1711	903605	53
8	094047	1680	996625	26	097422	1707	902578	52
9	095056	1676	996610	26	098446	1703	901554	51
10	096062	1673	996594	26	099468	1699	900532	50
11	9·097065	1668	9·996578	27	9·100487	1695	10·899513	49
12	098066	1665	996562	27	101504	1691	898496	48
13	099065	1661	996546	27	102519	1687	897481	47
14	100062	1657	996530	27	103532	1684	896468	46
15	101056	1653	996514	27	104542	1680	895458	45
16	102048	1649	996498	27	105550	1676	894450	44
17	103037	1645	996482	27	106556	1672	893444	43
18	104025	1641	996465	27	107559	1669	892441	42
19	105010	1638	996449	27	108560	1665	891440	41
20	105992	1634	996433	27	109559	1661	890441	40
21	9·106973	1630	9·996417	27	9·110556	1658	10·889444	39
22	107951	1627	996400	27	111551	1654	888449	38
23	108927	1623	996384	27	112543	1650	887457	37
24	109901	1619	996368	27	113533	1646	886467	36
25	110873	1616	996351	27	114521	1643	885479	35
26	111842	1612	996335	27	115507	1639	884493	34
27	112809	1608	996318	27	116491	1636	883509	33
28	113774	1605	996302	28	117472	1632	882528	32
29	114737	1601	996285	28	118452	1629	881548	31
30	115698	1597	996269	28	119429	1625	880571	30
31	9·116656	1594	9·996252	28	9·120404	1622	10·879596	29
32	117613	1590	996235	28	121377	1618	878623	28
33	118567	1587	996219	28	122348	1615	877652	27
34	119519	1583	996202	28	123317	1611	876683	26
35	120469	1580	996185	28	124284	1607	875716	25
36	121417	1576	996168	28	125249	1604	874751	24
37	122362	1573	996151	28	126211	1601	873789	23
38	123306	1569	996134	28	127172	1597	872828	22
39	124248	1566	996117	28	128130	1594	871870	21
40	125187	1562	996100	28	129087	1591	870913	20
41	9·126125	1559	9·996083	29	9·130041	1587	10·869959	19
42	127060	1556	996066	29	130994	1584	869006	18
43	127993	1552	996049	29	131944	1581	868056	17
44	128925	1549	996032	29	132893	1577	867107	16
45	129854	1545	996015	29	133839	1574	866161	15
46	130781	1542	995998	29	134784	1571	865216	14
47	131706	1539	995980	29	135726	1567	864274	13
48	132630	1535	995963	29	136667	1564	863333	12
49	133551	1532	995946	29	137605	1561	862395	11
50	134470	1529	995928	29	138542	1558	861458	10
51	9·135387	1525	9·995911	29	9·139476	1555	10·860524	9
52	136303	1522	995894	29	140409	1551	859591	8
53	137216	1519	995876	29	141340	1548	858660	7
54	138128	1516	995859	29	142269	1545	857731	6
55	139037	1512	995841	29	143196	1542	856804	5
56	139944	1509	995823	29	144121	1539	855879	4
57	140850	1506	995806	29	145044	1535	854956	3
58	141754	1503	995788	29	145966	1532	854034	2
59	142655	1500	995771	29	146885	1529	853115	1
60	143555	1496	995753	29	147803	1526	852197	0
	Cosine		Sine		Cotang.		Tang.	M.

82 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·143555	1496	9·995753	30	9·147803	1526	10.852197	60
1	144453	1493	995735	30	148718	1523	851282	59
2	145349	1490	995717	30	149632	1520	850368	58
3	146243	1487	995699	30	150544	1517	849456	57
4	147136	1484	995681	30	151454	1514	848546	56
5	148026	1481	995664	30	152363	1511	847637	55
6	148915	1478	995646	30	153269	1508	846731	54
7	149802	1475	995628	30	154174	1505	845826	53
8	150686	1472	995610	30	155077	1502	844923	52
9	151569	1469	995591	30	155978	1499	844022	51
10	152451	1466	995573	30	156877	1496	843123	50
11	9·153330	1463	9·995555	30	9·157775	1493	10·842225	49
12	154208	1460	995537	30	158671	1490	841329	48
13	155083	1457	995519	30	159565	1487	840435	47
14	155957	1454	995501	31	160457	1484	839543	46
15	156830	1451	995482	31	161347	1481	838653	45
16	157700	1448	995464	31	162236	1479	837764	44
17	158569	1445	995446	31	163123	1476	836877	43
18	159435	1442	995427	31	164008	1473	835992	42
19	160301	1439	995409	31	164892	1470	835108	41
20	161164	1436	995390	31	165774	1467	834226	40
21	9·162025	1433	9·995372	31	9·166654	1464	10·833346	39
22	162885	1430	995353	31	167532	1461	832468	38
23	163743	1427	995334	31	168409	1458	831591	37
24	164600	1424	995316	31	169284	1455	830716	36
25	165454	1422	995297	31	170157	1453	829843	35
26	166307	1419	995278	31	171029	1450	828971	34
27	167159	1416	995260	31	171899	1447	828101	33
28	168008	1413	995241	32	172767	1444	827233	32
29	168856	1410	995222	32	173634	1442	826366	31
30	169702	1407	995203	32	174499	1439	825501	30
31	9·170547	1405	9·995184	32	9·175362	1436	10·824638	29
32	171389	1402	995165	32	176224	1433	823776	28
33	172230	1399	995146	32	177084	1431	822916	27
34	173070	1396	995127	32	177942	1428	822058	26
35	173908	1394	995108	32	178799	1425	821201	25
36	174744	1391	995089	32	179655	1423	820345	24
37	175578	1388	995070	32	180508	1420	819492	23
38	176411	1386	995051	32	181360	1417	818640	22
39	177242	1383	995032	32	182211	1415	817789	21
40	178072	1380	995013	32	183059	1412	816941	20
41	9·178900	1377	9·994993	32	9·183907	1409	10·816093	19
42	179726	1374	994974	32	184752	1407	815248	18
43	180551	1372	994955	32	185597	1404	814403	17
44	181374	1369	994935	32	186439	1402	813561	16
45	182196	1366	994916	33	187280	1399	812720	15
46	183016	1364	994896	33	188120	1396	811880	14
47	183834	1361	994877	33	188958	1393	811042	13
48	184651	1359	994857	33	189794	1391	810206	12
49	185466	1356	994838	33	190629	1389	809371	11
50	186280	1353	994818	33	191462	1386	808538	10
51	9·187092	1351	9·994798	33	9·192294	1384	10·807706	9
52	187903	1348	994779	33	193124	1381	806876	8
53	188712	1346	994759	33	193953	1379	806047	7
54	189519	1343	994739	33	194780	1376	805220	6
55	190325	1341	994719	33	195606	1374	804394	5
56	191130	1338	994700	33	196430	1371	803570	4
57	191933	1336	994680	33	197253	1369	802747	3
58	192734	1333	994660	33	198074	1366	801926	2
59	193534	1330	994640	33	198894	1364	801106	1
60	194332	1328	994620	33	199713	1361	800287	0
	Cosine		Sine		Cotang.		Tang.	M.

81 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·194332	1328	9·994620	33	9·199713	1361	10·800287	60
1	195129	1326	994600	33	200529	1359	799471	59
2	195925	1323	994580	33	201345	1356	798655	58
3	196719	1321	994560	34	202159	1354	797841	57
4	197511	1318	994540	34	202971	1352	797029	56
5	198302	1316	994519	34	203782	1349	796218	55
6	199091	1313	994499	34	204592	1347	795408	54
7	199879	1311	994479	34	205400	1345	794600	53
8	200666	1308	994459	34	206207	1342	793793	52
9	201451	1306	994438	34	207013	1340	792987	51
10	202234	1304	994418	34	207817	1338	792183	50
11	9·203017	1301	9·994397	34	9·208619	1335	10·791381	49
12	203797	1299	994377	34	209420	1333	790580	48
13	204577	1296	994357	34	210220	1331	789780	47
14	205354	1294	994336	34	211018	1328	788982	46
15	206131	1292	994316	34	211815	1326	788185	45
16	206906	1289	994295	34	212611	1324	787389	44
17	207679	1287	994274	35	213405	1321	786595	43
18	208452	1285	994254	35	214198	1319	785802	42
19	209222	1282	994233	35	214989	1317	785011	41
20	209992	1280	994212	35	215780	1315	784220	40
21	9·210760	1278	9·994191	35	9·216568	1312	10·783432	39
22	211526	1275	994171	35	217356	1310	782644	38
23	212291	1273	994150	35	218142	1308	781858	37
24	213055	1271	994129	35	218926	1305	781074	36
25	213818	1268	994108	35	219710	1303	780290	35
26	214579	1266	994087	35	220492	1301	779508	34
27	215338	1264	994066	35	221272	1299	778728	33
28	216097	1261	994045	35	222052	1297	777948	32
29	216854	1259	994024	35	222830	1294	777170	31
30	217609	1257	994003	35	223606	1292	776394	30
31	9·218363	1255	9·993981	35	9·224382	1290	10·775618	29
32	219116	1253	993960	35	225156	1288	774844	28
33	219868	1250	993939	35	225929	1286	774071	27
34	220618	1248	993918	35	226700	1284	773300	26
35	221367	1246	993896	36	227471	1281	772529	25
36	222115	1244	993875	36	228239	1279	771761	24
37	222861	1242	993854	36	229007	1277	770993	23
38	223606	1239	993832	36	229773	1275	770227	22
39	224349	1237	993811	36	230539	1273	769461	21
40	225092	1235	993789	36	231302	1271	768698	20
41	9·225833	1233	9·993768	36	9·232065	1269	10·767935	19
42	226573	1231	993746	36	232826	1267	767174	18
43	227311	1228	993725	36	233586	1265	766414	17
44	228048	1226	993703	36	234345	1262	765655	16
45	228784	1224	993681	36	235103	1260	764897	15
46	229518	1222	993660	36	235859	1258	764141	14
47	230252	1220	993638	36	236614	1256	763386	13
48	230984	1218	993616	36	237368	1254	762632	12
49	231714	1216	993594	37	238120	1252	761880	11
50	232444	1214	993572	37	238872	1250	761128	10
51	9·233172	1212	9·993550	37	9·239622	1248	10·760378	9
52	233899	1209	993528	37	240371	1246	759629	8
53	234625	1207	993506	37	241118	1244	758882	7
54	235349	1205	993484	37	241865	1242	758135	6
55	236073	1203	993462	37	242610	1240	757390	5
56	236795	1201	993440	37	243354	1238	756646	4
57	237515	1199	993418	37	244097	1236	755903	3
58	238235	1197	993396	37	244839	1234	755161	2
59	238953	1195	993374	37	245579	1232	754421	1
60	239670	1193	993351	37	246319	1230	753681	0
	Cosine		Sine		Cotang.		Tang.	M.

[illegible] Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·239670	1193	9·993351	37	9·246319	1230	10·753681	60
1	240386	1191	993329	37	247057	1228	752943	59
2	241101	1189	993307	37	247794	1226	752206	58
3	241814	1187	993285	37	248530	1224	751470	57
4	242526	1185	993262	37	249264	1222	750736	56
5	243237	1183	993240	37	249998	1220	750002	55
6	243947	1181	993217	38	250730	1218	749270	54
7	244656	1179	993195	38	251461	1217	748539	53
8	245363	1177	993172	38	252191	1215	747809	52
9	246069	1175	993149	38	252920	1213	747080	51
10	246775	1173	993127	38	253648	1211	746352	50
11	9·247478	1171	9·993104	38	9·254374	1209	10·745626	49
12	248181	1169	993081	38	255100	1207	744900	48
13	248883	1167	993059	38	255824	1205	744176	47
14	249583	1165	993036	38	256547	1203	743453	46
15	250282	1163	993013	38	257269	1201	742731	45
16	250980	1161	992990	38	257990	1200	742010	44
17	251677	1159	992967	38	258710	1198	741290	43
18	252373	1158	992944	38	259429	1196	740571	42
19	253067	1156	992921	38	260146	1194	739854	41
20	253761	1154	992898	38	260863	1192	739137	40
21	9·254453	1152	9·992875	38	9·261578	1190	10·738422	39
22	255144	1150	992852	38	262292	1189	737708	38
23	255834	1148	992829	39	263005	1187	736995	37
24	256523	1146	992806	39	263717	1185	736283	36
25	257211	1144	992783	39	264428	1183	735572	35
26	257898	1142	992759	39	265138	1181	734862	34
27	258583	1141	992736	39	265847	1179	734153	33
28	259268	1139	992713	39	266555	1178	733445	32
29	259951	1137	992690	39	267261	1176	732739	31
30	260633	1135	992666	39	267967	1174	732033	30
31	9·261314	1133	9·992643	39	9·268671	1172	10·731329	29
32	261994	1131	992619	39	269375	1170	730625	28
33	262673	1130	992596	39	270077	1169	729923	27
34	263351	1128	992572	39	270779	1167	729221	26
35	264027	1126	992549	39	271479	1165	728521	25
36	264703	1124	992525	39	272178	1164	727822	24
37	265377	1122	992501	39	272876	1162	727124	23
38	266051	1120	992478	40	273573	1160	726427	22
39	266723	1119	992454	40	274269	1158	725731	21
40	267395	1117	992430	40	274964	1157	725036	20
41	9·268065	1115	9·992406	40	9·275658	1155	10·724342	19
42	268734	1113	992382	40	276351	1153	723649	18
43	269402	1111	992359	40	277043	1151	722957	17
44	270069	1110	992335	40	277734	1150	722266	16
45	270735	1108	992311	40	278424	1148	721576	15
46	271400	1106	992287	40	279113	1147	720887	14
47	272064	1105	992263	40	279801	1145	720199	13
48	272726	1103	992239	40	280488	1143	719512	12
49	273388	1101	992214	40	281174	1141	718826	11
50	274049	1099	992190	40	281858	1140	718142	10
51	9·274708	1098	9·992166	40	9·282542	1138	10·717458	9
52	275367	1096	992142	40	283225	1136	716775	8
53	276024	1094	992117	41	283907	1135	716093	7
54	276681	1092	992093	41	284588	1133	715412	6
55	277337	1091	992069	41	285268	1131	714732	5
56	277991	1089	992044	41	285947	1130	714053	4
57	278644	1087	992020	41	286624	1128	713376	3
58	279297	1085	991996	[illegible]	287301	1126	712699	2
59	279948	1084	991971	[illegible]	[illegible]	1125	712023	1
60	280599	1082	991947	[illegible]	[illegible]	1123	711348	0
	Cosine		Sine				Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·940296	2403	9·998344	19	8·941952	2421	11 058048	60
1	941738	2394	998333	19	943404	2413	056596	59
2	943174	2387	998322	19	944852	2405	055148	58
3	944606	2379	998311	19	946295	2397	053705	57
4	946034	2371	998300	19	947734	2390	052266	56
5	947456	2363	998289	19	949168	2382	050832	55
6	948874	2355	998277	19	950597	2374	049403	54
7	950287	2348	998266	19	952021	2366	047979	53
8	951696	2340	998255	19	953441	2360	046559	52
9	953100	2332	998243	19	954856	2351	045144	51
10	954499	2325	998232	19	956267	2344	043733	50
11	8·955894	2317	9·998220	19	8·957674	2337	11·042326	49
12	957284	2310	998209	19	959075	2329	040925	48
13	958670	2302	998197	19	960473	2323	039527	47
14	960052	2295	998186	19	961866	2314	038134	46
15	961429	2288	998174	19	963255	2307	036745	45
16	962801	2280	998163	19	964639	2300	035361	44
17	964170	2273	998151	19	966019	2293	033981	43
18	965534	2266	998139	20	967394	2286	032606	42
19	966893	2259	998128	20	968766	2279	031234	41
20	968249	2252	998116	20	970133	2271	029867	40
21	8·969600	2244	9·998104	20	8·971496	2265	11 028504	39
22	970947	2238	998092	20	972855	2257	027145	38
23	972289	2231	998080	20	974209	2251	025791	37
24	973628	2224	998068	20	975560	2244	024440	36
25	974962	2217	998056	20	976906	2237	023094	35
26	976293	2210	998044	20	978248	2230	021752	34
27	977619	2203	998032	20	979586	2223	020414	33
28	978941	2197	998020	20	980921	2217	019079	32
29	980259	2190	998008	20	982251	2210	017749	31
30	981573	2183	997996	20	983577	2204	016423	30
31	8·982883	2177	9·997984	20	8·984899	2197	11·015101	29
32	984189	2170	997972	20	986217	2191	013783	28
33	985491	2163	997959	20	987532	2184	012468	27
34	986789	2157	997947	20	988842	2178	011158	26
35	988083	2150	997935	21	990149	2171	009851	25
36	989374	2144	997922	21	991451	2165	008549	24
37	990660	2138	997910	21	992750	2158	007250	23
38	991943	2131	997897	21	994045	2152	005955	22
39	993222	2125	997885	21	995337	2146	004663	21
40	994497	2119	997872	21	996624	2140	003376	20
41	8·995768	2112	9·997860	21	8·997908	2134	11·002092	19
42	997036	2106	997847	21	999188	2127	000812	18
43	998299	2100	997835	21	9·000465	2121	10·999535	17
44	999560	2094	997822	21	001738	2115	998262	16
45	9·000816	2087	997809	21	003007	2109	996993	15
46	002069	2082	997797	21	004272	2103	995728	14
47	003318	2076	997784	21	005534	2097	994466	13
48	004563	2070	997771	21	006792	2091	993208	12
49	005805	2064	997758	21	008047	2085	991953	11
50	007044	2058	997745	21	009298	2080	990702	10
51	9·008278	2052	9·997732	21	9·010546	2074	10·989454	9
52	009510	2046	997719	21	011790	2068	988210	8
53	010737	2040	997706	21	013031	2062	986969	7
54	011962	2034	997693	22	014268	2056	985732	6
55	013182	2029	997680	22	015502	2051	984498	5
56	014400	2023	997667	22	016732	2045	983268	4
57	015613	2017	997654	22	017959	2040	982041	3
58	016824	2012	997641	22	019183	2033	980817	2
59	018031	2006	997628	22	020403	2028	979597	1
60	*019235*	2000	997614	22	021620	2023	978380	0
	Cosine		Sine		Cotang.		Tang.	M.

84 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·239670	1193	9·993351	37	9·246319	1230	10·753681	60
1	240386	1191	993329	37	247057	1228	752943	59
2	241101	1189	993307	37	247794	1226	752206	58
3	241814	1187	993285	37	248530	1224	751470	57
4	242526	1185	993262	37	249264	1222	750736	56
5	243237	1183	993240	37	249998	1220	750002	55
6	243947	1181	993217	38	250730	1218	749270	54
7	244656	1179	993195	38	251461	1217	748539	53
8	245363	1177	993172	38	252191	1215	747809	52
9	246069	1175	993149	38	252920	1213	747080	51
10	246775	1173	993127	38	253648	1211	746352	50
11	9·247478	1171	9·993104	38	9·254374	1209	10·745626	49
12	248181	1169	993081	38	255100	1207	744900	48
13	248883	1167	993059	38	255824	1205	744176	47
14	249583	1165	993036	38	256547	1203	743453	46
15	250282	1163	993013	38	257269	1201	742731	45
16	250980	1161	992990	38	257990	1200	742010	44
17	251677	1159	992967	38	258710	1198	741290	43
18	252373	1158	992944	38	259429	1196	740571	42
19	253067	1156	992921	38	260146	1194	739854	41
20	253761	1154	992898	38	260863	1192	739137	40
21	9·254453	1152	9·992875	38	9·261578	1190	10·738422	39
22	255144	1150	992852	38	262292	1189	737708	38
23	255834	1148	992829	39	263005	1187	736995	37
24	256523	1146	992806	39	263717	1185	736283	36
25	257211	1144	992783	39	264428	1183	735572	35
26	257898	1142	992759	39	265138	1181	734862	34
27	258583	1141	992736	39	265847	1179	734153	33
28	259268	1139	992713	39	266555	1178	733445	32
29	259951	1137	992690	39	267261	1176	732739	31
30	260633	1135	992666	39	267967	1174	732033	30
31	9·261314	1133	9·992643	39	9·268671	1172	10·731329	29
32	261994	1131	992619	39	269375	1170	730625	28
33	262673	1130	992596	39	270077	1169	729923	27
34	263351	1128	992572	39	270779	1167	729221	26
35	264027	1126	992549	39	271479	1165	728521	25
36	264703	1124	992525	39	272178	1164	727822	24
37	265377	1122	992501	39	272876	1162	727124	23
38	266051	1120	992478	40	273573	1160	726427	22
39	266723	1119	992454	40	274269	1158	725731	21
40	267395	1117	992430	40	274964	1157	725036	20
41	9·268065	1115	9·992406	40	9·275658	1155	10·724342	19
42	268734	1113	992382	40	276351	1153	723649	18
43	269402	1111	992359	40	277043	1151	722957	17
44	270069	1110	992335	40	277734	1150	722266	16
45	270735	1108	992311	40	278424	1148	721576	15
46	271400	1106	992287	40	279113	1147	720887	14
47	272064	1105	992263	40	279801	1145	720199	13
48	272726	1103	992239	40	280488	1143	719512	12
49	273388	1101	992214	40	281174	1141	718826	11
50	274049	1099	992190	40	281858	1140	718142	10
51	9·274708	1098	9·992166	40	9·282542	1138	10·717458	9
52	275367	1096	992142	40	283225	1136	716775	8
53	276024	1094	992117	41	283907	1135	716093	7
54	276681	1092	992093	41	284588	1133	715412	6
55	277337	1091	992069	41	285268	1131	714732	5
56	277991	1089	992044	41	285947	1130	714053	4
57	278644	1087	992020	41	286624	1128	713376	3
58	279297	1086	991996	41	287301	1126	712699	2
59	279948	1084	991971	41	287977	1125	712023	1
60	280599	1082	991947	41	288652	1123	711348	0
	Cosine		Sine		Cotang.		Tang.	M.

79 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang	
0	9·085894	1713	9·996751	26	9·089144	1738	10·910856	60
1	086922	1709	996735	26	090187	1734	909813	59
2	087947	1704	996720	26	091228	1730	908772	58
3	088970	1700	996704	26	092266	1727	907734	57
4	089990	1696	996688	26	093302	1722	906698	56
5	091008	1692	996673	26	094336	1719	905664	55
6	092024	1688	996657	26	095367	1715	904633	54
7	093037	1684	996641	26	096395	1711	903605	53
8	094047	1680	996625	26	097422	1707	902578	52
9	095056	1676	996610	26	098446	1703	901554	51
10	096062	1673	996594	26	099468	1699	900532	50
11	9·097065	1668	9·996578	27	9·100487	1695	10·899513	49
12	098066	1665	996562	27	101504	1691	898496	48
13	099065	1661	996546	27	102519	1687	897481	47
14	100062	1657	996530	27	103532	1684	896468	46
15	101056	1653	996514	27	104542	1680	895458	45
16	102048	1649	996498	27	105550	1676	894450	44
17	103037	1645	996482	27	106556	1672	893444	43
18	104025	1641	996465	27	107559	1669	892441	42
19	105010	1638	996449	27	108560	1665	891440	41
20	105992	1634	996433	27	109559	1661	890441	40
21	9·106973	1630	9·996417	27	9·110556	1658	10·889444	39
22	107951	1627	996400	27	111551	1654	888449	38
23	108927	1623	996384	27	112543	1650	887457	37
24	109901	1619	996368	27	113533	1646	886467	36
25	110873	1616	996351	27	114521	1643	885479	35
26	111842	1612	996335	27	115507	1639	884493	34
27	112809	1608	996318	27	116491	1636	883509	33
28	113774	1605	996302	28	117472	1632	882528	32
29	114737	1601	996285	28	118452	1629	881548	31
30	115698	1597	996269	28	119429	1625	880571	30
31	9·116656	1594	9·996252	28	9·120404	1622	10·879596	29
32	117613	1590	996235	28	121377	1618	878623	28
33	118567	1587	996219	28	122348	1615	877652	27
34	119519	1583	996202	28	123317	1611	876683	26
35	120469	1580	996185	28	124284	1607	875716	25
36	121417	1576	996168	28	125249	1604	874751	24
37	122362	1573	996151	28	126211	1601	873789	23
38	123306	1569	996134	28	127172	1597	872828	22
39	124248	1566	996117	28	128130	1594	871870	21
40	125187	1562	996100	28	129087	1591	870913	20
41	9·126125	1559	9·996083	29	9·130041	1587	10·869959	19
42	127060	1556	996066	29	130994	1584	869006	18
43	127993	1552	996049	29	131944	1581	868056	17
44	128925	1549	996032	29	132893	1577	867107	16
45	129854	1545	996015	29	133839	1574	866161	15
46	130781	1542	995998	29	134784	1571	865216	14
47	131706	1539	995980	29	135726	1567	864274	13
48	132630	1535	995963	29	136667	1564	863333	12
49	133551	1532	995946	29	137605	1561	862395	11
50	134470	1529	995928	29	138542	1558	861458	10
51	9·135387	1525	9·995911	29	9·139476	1555	10·860524	9
52	136303	1522	995894	29	140409	1551	859591	8
53	137216	1519	995876	29	141340	1548	858660	7
54	138128	1516	995859	29	142269	1545	857731	6
55	139037	1512	995841	29	143196	1542	856804	5
56	139944	1509	995823	29	144121	1539	855879	4
57	140850	1506	995806	29	145044	1535	854956	3
58	141754	1503	995788	29	145966	1532	854034	2
59	142655	1500	995771	29	146885	1529	853115	1
60	143555	1496	995753	29	147803	1526	852197	0
	Cosine		Sine		Cotang.		Tang.	M.

82 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·143555	1496	9·995753	30	9·147803	1526	10.852197	60
1	144453	1493	995735	30	148718	1523	851282	59
2	145349	1490	995717	30	149632	1520	850368	58
3	146243	1487	995699	30	150544	1517	849456	57
4	147136	1484	995681	30	151454	1514	848546	56
5	148026	1481	995664	30	152363	1511	847637	55
6	148915	1478	995646	30	153269	1508	846731	54
7	149802	1475	995628	30	154174	1505	845826	53
8	150686	1472	995610	30	155077	1502	844923	52
9	151569	1469	995591	30	155978	1499	844022	51
10	152451	1466	995573	30	156877	1496	843123	50
11	9·153330	1463	9·995555	30	9·157775	1493	10·842225	49
12	154208	1460	995537	30	158671	1490	841329	48
13	155083	1457	995519	30	159565	1487	840435	47
14	155957	1454	995501	31	160457	1484	839543	46
15	156830	1451	995482	31	161347	1481	838653	45
16	157700	1448	995464	31	162236	1479	837764	44
17	158569	1445	995446	31	163123	1476	836877	43
18	159435	1442	995427	31	164008	1473	835992	42
19	160301	1439	995409	31	164892	1470	835108	41
20	161164	1436	995390	31	165774	1467	834226	40
21	9·162025	1433	9·995372	31	9·166654	1464	10·833346	39
22	162885	1430	995353	31	167532	1461	832468	38
23	163743	1427	995334	31	168409	1458	831591	37
24	164600	1424	995316	31	169284	1455	830716	36
25	165454	1422	995297	31	170157	1453	829843	35
26	166307	1419	995278	31	171029	1450	828971	34
27	167159	1416	995260	31	171899	1447	828101	33
28	168008	1413	995241	32	172767	1444	827233	32
29	168856	1410	995222	32	173634	1442	826366	31
30	169702	1407	995203	32	174499	1439	825501	30
31	9·170547	1405	9·995184	32	9·175362	1436	10·824638	29
32	171389	1402	995165	32	176224	1433	823776	28
33	172230	1399	995146	32	177084	1431	822916	27
34	173070	1396	995127	32	177942	1428	822058	26
35	173908	1394	995108	32	178799	1425	821201	25
36	174744	1391	995089	32	179655	1423	820345	24
37	175578	1388	995070	32	180508	1420	819492	23
38	176411	1386	995051	32	181360	1417	818640	22
39	177242	1383	995032	32	182211	1415	817789	21
40	178072	1380	995013	32	183059	1412	816941	20
41	9·178900	1377	9·994993	32	9·183907	1409	10·816093	19
42	179726	1374	994974	32	184752	1407	815248	18
43	180551	1372	994955	32	185597	1404	814403	17
44	181374	1369	994935	32	186439	1402	813561	16
45	182196	1366	994916	33	187280	1399	812720	15
46	183016	1364	994896	33	188120	1396	811880	14
47	183834	1361	994877	33	188958	1393	811042	13
48	184651	1359	994857	33	189794	1391	810206	12
49	185466	1356	994838	33	190629	1389	809371	11
50	186280	1353	994818	33	191462	1386	808538	10
51	9·187092	1351	9·994798	33	9·192294	1384	10·807706	9
52	187903	1348	994779	33	193124	1381	806876	8
53	188712	1346	994759	33	193953	1379	806047	7
54	189519	1343	994739	33	194780	1376	805220	6
55	190325	1341	994719	33	195606	1374	804394	5
56	191130	1338	994700	33	196430	1371	803570	4
57	191933	1336	994680	33	197253	1369	802747	3
58	192734	1333	994660	33	198074	1366	801926	2
59	193534	1330	994640	33	198894	1364	801106	1
60	194332	1328	994620	33	199713	1361	800287	0
	Cosine		Sine		Cotang.		Tang.	M.

81 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·194332	1328	9·994620	33	9·199713	1361	10·800287	60
1	195129	1326	994600	33	200529	1359	799471	59
2	195925	1323	994580	33	201345	1356	798655	58
3	196719	1321	994560	34	202159	1354	797841	57
4	197511	1318	994540	34	202971	1352	797029	56
5	198302	1316	994519	34	203782	1349	796218	55
6	199091	1313	994499	34	204592	1347	795408	54
7	199879	1311	994479	34	205400	1345	794600	53
8	200666	1308	994459	34	206207	1342	793793	52
9	201451	1306	994438	34	207013	1340	792987	51
10	202234	1304	994418	34	207817	1338	792183	50
11	9·203017	1301	9·994397	34	9·208619	1335	10·791381	49
12	203797	1299	994377	34	209420	1333	790580	48
13	204577	1296	994357	34	210220	1331	789780	47
14	205354	1294	994336	34	211018	1328	788982	46
15	206131	1292	994316	34	211815	1326	788185	45
16	206906	1289	994295	34	212611	1324	787389	44
17	207679	1287	994274	35	213405	1321	786595	43
18	208452	1285	994254	35	214198	1319	785802	42
19	209222	1282	994233	35	214989	1317	785011	41
20	209992	1280	994212	35	215780	1315	784220	40
21	9·210760	1278	9·994191	35	9·216568	1312	10·783432	39
22	211526	1275	994171	35	217356	1310	782644	38
23	212291	1273	994150	35	218142	1308	781858	37
24	213055	1271	994129	35	218926	1305	781074	36
25	213818	1268	994108	35	219710	1303	780290	35
26	214579	1266	994087	35	220492	1301	779508	34
27	215338	1264	994066	35	221272	1299	778728	33
28	216097	1261	994045	35	222052	1297	777948	32
29	216854	1259	994024	35	222830	1294	777170	31
30	217609	1257	994003	35	223606	1292	776394	30
31	9·218363	1255	9·993981	35	9·224382	1290	10·775618	29
32	219116	1253	993960	35	225156	1288	774844	28
33	219868	1250	993939	35	225929	1286	774071	27
34	220618	1248	993918	35	226700	1284	773300	26
35	221367	1246	993896	36	227471	1281	772529	25
36	222115	1244	993875	36	228239	1279	771761	24
37	222861	1242	993854	36	229007	1277	770993	23
38	223606	1239	993832	36	229773	1275	770227	22
39	224349	1237	993811	36	230539	1273	769461	21
40	225092	1235	993789	36	231302	1271	768698	20
41	9·225833	1233	9·993768	36	9·232065	1269	10·767935	19
42	226573	1231	993746	36	232826	1267	767174	18
43	227311	1228	993725	36	233586	1265	766414	17
44	228048	1226	993703	36	234345	1262	765655	16
45	228784	1224	993681	36	235103	1260	764897	15
46	229518	1222	993660	36	235859	1258	764141	14
47	230252	1220	993638	36	236614	1256	763386	13
48	230984	1218	993616	36	237368	1254	762632	12
49	231714	1216	993594	37	238120	1252	761880	11
50	232444	1214	993572	37	238872	1250	761128	10
51	9·233172	1212	9·993550	37	9·239622	1248	10·760378	9
52	233899	1209	993528	37	240371	1246	759629	8
53	234625	1207	993506	37	241118	1244	758882	7
54	235349	1205	993484	37	241865	1242	758135	6
55	236073	1203	993462	37	242610	1240	757390	5
56	236795	1201	993440	37	243354	1238	756646	4
57	237515	1199	993418	37	244097	1236	755903	3
58	238235	1197	993396	37	244839	1234	755161	2
59	238953	1195	993374	37	245579	1232	754421	1
60	239670	1193	993351	37	246319	1230	753681	0
	Cosine		Sine		Cotang.		Tang.	M.

80 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	′
0	9·317879	990	9·990404	45	9·327474	1035	10·672526	60
1	318473	988	990378	45	328095	1033	671905	59
2	319066	987	990351	45	328715	1032	671285	58
3	319658	986	990324	45	329334	1030	670666	57
4	320249	984	990297	45	329953	1029	670047	56
5	320840	983	990270	45	330570	1028	669430	55
6	321430	982	990243	45	331187	1026	668813	54
7	322019	980	990215	45	331803	1025	668197	53
8	322607	979	990188	45	332418	1024	667582	52
9	323194	977	990161	45	333033	1023	666967	51
10	323780	976	990134	45	333646	1021	666354	50
11	9·324366	975	9·990107	46	9·334259	1020	10·665741	49
12	324950	973	990079	46	334871	1019	665129	48
13	325534	972	990052	46	335482	1017	664518	47
14	326117	970	990025	46	336093	1016	663907	46
15	326700	969	989997	46	336702	1015	663298	45
16	327281	968	989970	46	337311	1013	662689	44
17	327862	966	989942	46	337919	1012	662081	43
18	328442	965	989915	46	338527	1011	661473	42
19	329021	964	989887	46	339133	1010	660867	41
20	329599	962	989860	46	339739	1008	660261	40
21	9·330176	961	9·989832	46	9·340344	1007	10·659656	39
22	330753	960	989804	46	340948	1006	659052	38
23	331329	958	989777	46	341552	1004	658448	37
24	331903	957	989749	47	342155	1003	657845	36
25	332478	956	989721	47	342757	1002	657243	35
26	333051	954	989693	47	343358	1000	656642	34
27	333624	953	989665	47	343958	999	656042	33
28	334195	952	989637	47	344558	998	655442	32
29	334766	950	989609	47	345157	997	654843	31
30	335337	949	989582	47	345755	996	654245	30
31	9·335906	948	9·989553	47	9·346353	994	10·653647	29
32	336475	946	989525	47	346949	993	653051	28
33	337043	945	989497	47	347545	992	652455	27
34	337610	944	989469	47	348141	991	651859	26
35	338176	943	989441	47	348735	990	651265	25
36	338742	941	989413	47	349329	988	650671	24
37	339306	940	989384	47	349922	987	650078	23
38	339871	939	989356	47	350514	986	649486	22
39	340434	937	989328	47	351106	985	648894	21
40	340996	936	989300	47	351697	983	648303	20
41	9·341558	935	9·989271	47	9·352287	982	10 647713	19
42	342119	934	989243	47	352876	981	647124	18
43	342679	932	989214	47	353465	980	646535	17
44	343239	931	989186	47	354053	979	645947	16
45	343797	930	989157	47	354640	977	645360	15
46	344355	929	989128	48	355227	976	644773	14
47	344912	927	989100	48	355813	975	644187	13
48	345469	926	989071	48	356398	974	643602	12
49	346024	925	989042	48	356982	973	643018	11
50	346579	924	989014	48	357566	971	642434	10
51	9·347134	922	9·988985	48	9·358149	970	10·641851	9
52	347687	921	988956	48	358731	969	641269	8
53	348240	920	988927	48	359313	968	640687	7
54	348792	919	988898	48	359893	967	640107	6
55	349343	917	988869	48	360474	966	639526	5
56	349893	916	988840	48	361053	965	638947	4
57	350443	915	988811	49	361632	963	638368	3
58	350992	914	988782	49	362210	962	637790	2
59	351540	913	988753	49	362787	961	637213	1
60	352088	911	988724	49	363364	960	636636	0
	Cosine		Sine		Cotang.		Tang.	M.

77 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·352088	911	9·988724	49	9·363364	960	10·636636	60
1	352635	910	988695	49	363940	959	636060	59
2	353181	909	988666	49	364515	958	635485	58
3	353726	908	988636	49	365090	957	634910	57
4	354271	907	988607	49	365664	955	634336	56
5	354815	905	988578	49	366237	954	633763	55
6	355358	904	988548	49	366810	953	633190	54
7	355901	903	988519	49	367382	952	632618	53
8	356443	902	988489	49	367953	951	632047	52
9	356984	901	988460	49	368524	950	631476	51
10	357524	899	988430	49	369094	949	630906	50
11	9·358064	898	9·988401	49	9·369663	948	10·630337	49
12	358603	897	988371	49	370232	946	629768	48
13	359141	896	988342	49	370799	945	629201	47
14	359678	895	988312	50	371367	944	628633	46
15	360215	893	988282	50	371933	943	628067	45
16	360752	892	988252	50	372499	942	627501	44
17	361287	891	988223	50	373064	941	626936	43
18	361822	890	988193	50	373629	940	626371	42
19	362356	889	988163	50	374193	939	625807	41
20	362889	888	988133	50	374756	938	625244	40
21	9·363422	887	9·988103	50	9·375319	937	10·624681	39
22	363954	885	988073	50	375881	935	624119	38
23	364485	884	988043	50	376442	934	623558	37
24	365016	883	988013	50	377003	933	622997	36
25	365546	882	987983	50	377563	932	622437	35
26	366075	881	987953	50	378122	931	621878	34
27	366604	880	987922	50	378681	930	621319	33
28	367131	879	987892	50	379239	929	620761	32
29	367659	877	987862	50	379797	928	620203	31
30	368185	876	987832	51	380354	927	619646	30
31	9·368711	875	9·987801	51	9·380910	926	10·619090	29
32	369236	874	987771	51	381466	925	618534	28
33	369761	873	987740	51	382020	924	617980	27
34	370285	872	987710	51	382575	923	617425	26
35	370808	871	987679	51	383129	922	616871	25
36	371330	870	987649	51	383682	921	616318	24
37	371852	869	987618	51	384234	920	615766	23
38	372373	867	987588	51	384786	919	615214	22
39	372894	866	987557	51	385337	918	614663	21
40	373414	865	987526	51	385888	917	614112	20
41	9·373933	864	9·987496	51	9·386438	915	10·613562	19
42	374452	863	987465	51	386987	914	613013	18
43	374970	862	987434	51	387536	913	612464	17
44	375487	861	987403	52	388084	912	611916	16
45	376003	860	987372	52	388631	911	611369	15
46	376519	859	987341	52	389178	910	610822	14
47	377035	858	987310	52	389724	909	610276	13
48	377549	857	987279	52	390270	908	609730	12
49	378063	856	987248	52	390815	907	609185	11
50	378577	854	987217	52	391360	906	608640	10
51	9·379089	853	9·987186	52	9·391903	905	10·608097	9
52	379601	852	987155	52	392447	904	607553	8
53	380113	851	987124	52	392989	903	607011	7
54	380624	850	987092	52	393531	902	606469	6
55	381134	849	987061	52	394073	901	605927	5
56	381643	848	987030	52	394614	900	605386	4
57	382152	847	986998	52	395154	899	604846	3
58	382661	846	986967	52	395694	898	604306	2
59	383168	845	986936	52	396233	897	603767	1
60	383675	844	986904	52	396771	896	603229	0
	Cosine		Sine		Cotang.		Tang.	M.

76 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·383675	844	9·986904	52	9·396771	896	10·603229	60
1	384182	843	986873	53	397309	896	602691	59
2	384687	842	986841	53	397846	895	602154	58
3	385192	841	986809	53	398383	894	601617	57
4	385697	840	986778	53	398919	893	601081	56
5	386201	839	986746	53	399455	892	600545	55
6	386704	838	986714	53	399990	891	600010	54
7	387207	837	986683	53	400524	890	599476	53
8	387709	836	986651	53	401058	889	598942	52
9	388210	835	986619	53	401591	888	598409	51
10	388711	834	986587	53	402124	887	597876	50
11	9·389211	833	9·986555	53	9·402656	886	10·597344	49
12	389711	832	986523	53	403187	885	596813	48
13	390210	831	986491	53	403718	884	596282	47
14	390708	830	986459	53	404249	883	595751	46
15	391206	828	986427	53	404778	882	595222	45
16	391703	827	986395	53	405308	881	594692	44
17	392199	826	986363	54	405836	880	594164	43
18	392695	825	986331	54	406364	879	593636	42
19	393191	824	986299	54	406892	878	593108	41
20	393685	823	986266	54	407419	877	592581	40
21	9·394179	822	9·986234	54	9·407945	876	10·592055	39
22	394673	821	986202	54	408471	875	591529	38
23	395166	820	986169	54	408997	874	591003	37
24	395658	819	986137	54	409521	874	590479	36
25	396150	818	986104	54	410045	873	589955	35
26	396641	817	986072	54	410569	872	589431	34
27	397132	817	986039	54	411092	871	588908	33
28	397621	816	986007	54	411615	870	588385	32
29	398111	815	985974	54	412137	869	587863	31
30	398600	814	985942	54	412658	868	587342	30
31	9·399088	813	9·985909	55	9·413179	867	10·586821	29
32	399575	812	985876	55	413699	866	586301	28
33	400062	811	985843	55	414219	865	585781	27
34	400549	810	985811	55	414738	864	585262	26
35	401035	809	985778	55	415257	864	584743	25
36	401520	808	985745	55	415775	863	584225	24
37	402005	807	985712	55	416293	862	583707	23
38	402489	806	985679	55	416810	861	583190	22
39	402972	805	985646	55	417326	860	582674	21
40	403455	804	985613	55	417842	859	582158	20
41	9·403938	803	9·985580	55	9·418358	858	10·581642	19
42	404420	802	985547	55	418873	857	581127	18
43	404901	801	985514	55	419387	856	580613	17
44	405382	800	985480	55	419901	855	580099	16
45	405862	799	985447	55	420415	855	579585	15
46	406341	798	985414	56	420927	854	579073	14
47	406820	797	985380	56	421440	853	578560	13
48	407299	796	985347	56	421952	852	578048	12
49	407777	795	985314	56	422463	851	577537	11
50	408254	794	985280	56	422974	850	577026	10
51	9·408731	794	9·985247	56	9·423484	849	10·576516	9
52	409207	793	985213	56	423993	848	576007	8
53	409682	792	985180	56	424503	848	575497	7
54	410157	791	985146	56	425011	847	574989	6
55	410632	790	985113	56	425519	846	574481	5
56	411106	789	985079	56	426027	845	573973	4
57	411579	788	985045	56	426534	844	573466	3
58	412052	787	985011	56	427041	843	572959	2
59	412524	786	984978	56	427547	843	572453	1
60	412996	785	984944	56	428052	842	571948	0
	Cosine		Sine		Cotang.		Tang.	M.

75 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·412996	785	9·984944	57	9·428052	842	10·571948	60
1	413467	784	984910	57	428557	841	571443	59
2	413938	783	984876	57	429062	840	570938	58
3	414408	783	984842	57	429566	839	570434	57
4	414878	782	984808	57	430070	838	569930	56
5	415347	781	984774	57	430573	837	569427	55
6	415815	780	984740	57	431075	837	568925	54
7	416283	779	984706	57	431577	836	568423	53
8	416751	778	984672	57	432079	835	567921	52
9	417217	777	984637	57	432580	834	567420	51
10	417684	776	984603	57	433080	833	566920	50
11	9·418150	775	9·984569	57	9·433580	832	10·566420	49
12	418615	774	984535	57	434080	832	565920	48
13	419079	773	984500	57	434579	831	565421	47
14	419544	773	984466	57	435078	830	564922	46
15	420007	772	984432	58	435576	829	564424	45
16	420470	771	984397	58	436073	828	563927	44
17	420933	770	984363	58	436570	828	563430	43
18	421395	769	984328	58	437067	827	562933	42
19	421857	768	984294	58	437563	826	562437	41
20	422318	767	984259	58	438059	825	561941	40
21	9·422778	767	9·984224	58	9·438554	824	10·561446	39
22	423238	766	984190	58	439048	823	560952	38
23	423697	765	984155	58	439543	823	560457	37
24	424156	764	984120	58	440036	822	559964	36
25	424615	763	984085	58	440529	821	559471	35
26	425073	762	984050	58	441022	820	558978	34
27	425530	761	984015	58	441514	819	558486	33
28	425987	760	983981	58	442006	819	557994	32
29	426443	760	983946	58	442497	818	557503	31
30	426899	759	983911	58	442988	817	557012	30
31	9·427354	758	9·983875	58	9·443479	816	10·556521	29
32	427809	757	983840	59	443968	816	556032	28
33	428263	756	983805	59	444458	815	555542	27
34	428717	755	983770	59	444947	814	555053	26
35	429170	754	983735	59	445435	813	554565	25
36	429623	753	983700	59	445923	812	554077	24
37	430075	752	983664	59	446411	812	553589	23
38	430527	752	983629	59	446898	811	553102	22
39	430978	751	983594	59	447384	810	552616	21
40	431429	750	983558	59	447870	809	552130	20
41	9·431879	749	9·983523	59	9·448356	809	10·551644	19
42	432329	749	983487	59	448841	808	551159	18
43	432778	748	983452	59	449326	807	550674	17
44	433226	747	983416	59	449810	806	550190	16
45	433675	746	983381	59	450294	806	549706	15
46	434122	745	983345	59	450777	805	549223	14
47	434569	744	983309	59	451260	804	548740	13
48	435016	744	983273	60	451743	803	548257	12
49	435462	743	983238	60	452225	802	547775	11
50	435908	742	983202	60	452706	802	547294	10
51	9·436353	741	9·983166	60	9·453187	801	10·546813	9
52	436798	740	983130	60	453668	800	546332	8
53	437242	740	983094	60	454148	799	545852	7
54	437686	739	983058	60	454628	799	545372	6
55	438129	738	983022	60	455107	798	544893	5
56	438572	737	982986	60	455586	797	544414	4
57	439014	736	982950	60	456064	796	543936	3
58	439456	736	982914	60	456542	796	543458	2
59	439897	735	982878	60	457019	795	542981	1
60	440338	734	982842	60	457496	794	542504	0
	Cosine		Sine		Cotang		Tang.	M.

Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.
0	9·440338	734	9·982842	60	9·457496	794	10·542504
1	440778	733	982805	60	457973	793	542027
2	441218	732	982769	61	458449	793	541551
3	441658	731	982733	61	458925	792	541075
4	442096	731	982696	61	459400	791	540600
5	442535	730	982660	61	459875	790	540125
6	442973	729	982624	61	460349	790	539651
7	443410	728	982587	61	460823	789	539177
8	443847	727	982551	61	461297	788	538703
9	444284	727	982514	61	461770	788	538230
10	444720	726	982477	61	462242	787	537758
11	9·445155	725	9·982441	61	9·462714	786	10·537286
12	445590	724	982404	61	463186	785	536814
13	446025	723	982367	61	463658	785	536342
14	446459	723	982331	61	464129	784	535871
15	446893	722	982294	61	464599	783	535401
16	447326	721	982257	61	465069	783	534931
17	447759	720	982220	62	465539	782	534461
18	448191	720	982183	62	466008	781	533992
19	448623	719	982146	62	466476	780	533524
20	449054	718	982109	62	466945	780	533055
21	9·449485	717	9·982072	62	9·467413	779	10·532587
22	449915	716	982035	62	467880	778	532120
23	450345	716	981998	62	468347	778	531653
24	450775	715	981961	62	468814	777	531186
25	451204	714	981924	62	469280	776	530720
26	451632	713	981886	62	469746	775	530254
27	452060	713	981849	62	470211	775	529789
28	452488	712	981812	62	470676	774	529324
29	452915	711	981774	62	471141	773	528859
30	453342	710	981737	62	471605	773	528395
31	9·453768	710	9·981699	63	9·472068	772	10·527932
32	454194	709	981662	63	472532	771	527468
33	454619	708	981625	63	472995	771	527005
34	455044	707	981587	63	473457	770	526543
35	455469	707	981549	63	473919	769	526081
36	455893	706	981512	63	474381	769	525619
37	456316	705	981474	63	474842	768	525158
38	456739	704	981436	63	475303	767	524697
39	457162	704	981399	63	475763	767	524237
40	457584	703	981361	63	476223	766	523777
41	9·458006	702	9·981323	63	9·476683	765	10·523317
42	458427	701	981285	63	477142	765	522858
43	458848	701	981247	63	477601	764	522399
44	459268	700	981209	63	478059	763	521941
45	459688	699	981171	63	478517	763	521483
46	460108	698	981133	64	478975	762	521025
47	460527	698	981095	64	479432	761	520568
48	460946	697	981057	64	479889	761	520111
49	461364	696	981019	64	480345	760	519655
50	461782	695	980981	64	480801	759	519199
51	9·462199	695	9·980942	64	9·481257	759	10·518743
52	462616	694	980904	64	481712	758	518288
53	463032	693	980866	64	482167	757	517833
54	463448	693	980827	64	482621	757	517379
55	463864	692	980789	64	483075	756	516925
56	464279	691	980750	64	483529	755	516471
57	464694	690	980712	64	483982	755	516018
58	465108	690	980673	64	484435	754	515565
59	465522	689	980635	64	484887	753	515113
60	465935	688	980596	64	485339	753	514661
	Cosine		Sine		Cotang.		Tang.

73 Degrees

LOGARITHMIC SINES, COSINES, [illegible]

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	M.
0	9·465935	688	9·980596	64	[illegible]	[illegible]	[illegible]	60
1	466348	688	980558	64	[illegible]	[illegible]	[illegible]	59
2	466761	687	980519	65	[illegible]	[illegible]	[illegible]	58
3	467173	686	980480	65	[illegible]	[illegible]	[illegible]	57
4	467585	685	980442	65	[illegible]	[illegible]	[illegible]	56
5	467996	685	980403	65	[illegible]	[illegible]	[illegible]	55
6	468407	684	980364	65	[illegible]	[illegible]	[illegible]	54
7	468817	683	980325	65	[illegible]	[illegible]	[illegible]	53
8	469227	683	980286	65	[illegible]	[illegible]	[illegible]	52
9	469637	682	980247	65	[illegible]	[illegible]	[illegible]	51
10	470046	681	980208	65	[illegible]	[illegible]	[illegible]	50
11	9·470455	680	9·980169	65	[illegible]	[illegible]	[illegible]	49
12	470863	680	980130	65	[illegible]	[illegible]	[illegible]	48
13	471271	679	980091	65	[illegible]	[illegible]	[illegible]	47
14	471679	678	980052	65	[illegible]	[illegible]	[illegible]	46
15	472086	678	980012	65	[illegible]	[illegible]	[illegible]	45
16	472492	677	979973	65	[illegible]	[illegible]	[illegible]	44
17	472898	676	979934	66	[illegible]	[illegible]	[illegible]	43
18	473304	676	979895	66	[illegible]	[illegible]	[illegible]	42
19	473710	675	979855	66	[illegible]	[illegible]	[illegible]	41
20	474115	674	979816	66	[illegible]	[illegible]	[illegible]	40
21	9·474519	674	9·979776	66	[illegible]	[illegible]	[illegible]	39
22	474923	673	979737	66	[illegible]	[illegible]	[illegible]	38
23	475327	672	979697	66	[illegible]	[illegible]	[illegible]	37
24	475730	672	979658	66	[illegible]	[illegible]	[illegible]	36
25	476133	671	979618	66	496515	737	503485	35
26	476536	670	979579	66	496957	736	503043	34
27	476938	669	979539	66	497400	736	502600	33
28	477340	669	979499	66	497841	735	502159	32
29	477741	668	979459	66	498282	734	501718	31
30	478142	667	979420	66	498722	734	501278	30
31	9·478542	667	9·979380	66	9·499163	733	10·500837	29
32	478942	666	979340	66	499602	733	500398	28
33	479342	665	979300	67	500042	732	499958	27
34	479741	665	979260	67	500481	731	499519	26
35	480140	664	979220	67	500920	731	499080	25
36	480539	663	979180	67	501359	730	498641	24
37	480937	663	979140	67	501797	730	498203	23
38	481334	662	979100	67	502235	729	497765	22
39	481731	661	979059	67	502672	728	497328	21
40	482128	661	979019	67	503109	728	496891	20
41	9·482525	660	9·978979	67	9·503546	727	10·496454	19
42	482921	659	978939	67	503982	727	496018	18
43	483316	659	978898	67	504418	726	495582	17
44	483712	658	978858	67	504854	725	495146	16
45	484107	657	978817	67	505289	725	494711	15
46	484501	657	978777	67	505724	724	494276	14
47	484895	656	978736	67	506159	724	493841	13
48	485289	655	978696	68	506593	723	493407	12
49	485682	655	978655	68	507027	722	492973	11
50	486075	654	978615	68	507460	722	492540	10
51	9·486467	653	9·978574	68	9·507893	721	10·492107	9
52	486860	653	978533	68	508326	721	491674	8
53	487251	652	978493	68	508759	720	491241	7
54	487643	651	978452	68	509191	719	490809	6
55	488034	651	978411	68	509622	719	490378	5
56	488424	650	978370	68	510054	718	489946	4
57	488814	650	978329	68	510485	718	489515	3
58	489204	649	978288	68	510916	717	489084	2
59	489593	648	978247	68	511346	716	488654	1
60	489982	648	978206	68	511776	716	488224	0
	Cosine		Sine		Cotang.		Tang.	M.

72 Degrees

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·489982	648	9·978206	68	9·511776	716	10·488224	60
1	490371	648	978165	68	512206	716	487794	59
2	490759	647	978124	68	512635	715	487365	58
3	491147	646	978083	69	513064	714	486936	57
4	491535	646	978042	69	513493	714	486507	56
5	491922	645	978001	69	513921	713	486079	55
6	492308	644	977959	69	514349	713	485651	54
7	492695	644	977918	69	514777	712	485223	53
8	493081	643	977877	69	515204	712	484796	52
9	493466	642	977835	69	515631	711	484369	51
10	493851	642	977794	69	516057	710	483943	50
11	9·494236	641	9·977752	69	9·516484	710	10·483516	49
12	494621	641	977711	69	516910	709	483090	48
13	495005	640	977669	69	517335	709	482665	47
14	495388	639	977628	69	517761	708	482239	46
15	495772	639	977586	69	518185	708	481815	45
16	496154	638	977544	70	518610	707	481390	44
17	496537	637	977503	70	519034	706	480966	43
18	496919	637	977461	70	519458	706	480542	42
19	497301	636	977419	70	519882	705	480118	41
20	497682	636	977377	70	520305	705	479695	40
21	9·498064	635	9·977335	70	9·520728	704	10·479272	39
22	498444	634	977293	70	521151	703	478849	38
23	498825	634	977251	70	521573	703	478427	37
24	499204	633	977209	70	521995	703	478005	36
25	499584	632	977167	70	522417	702	477583	35
26	499963	632	977125	70	522838	702	477162	34
27	500342	631	977083	70	523259	701	476741	33
28	500721	631	977041	70	523680	701	476320	32
29	501099	630	976999	70	524100	700	475900	31
30	501476	629	976957	70	524520	699	475480	30
31	9·501854	629	9·976914	70	9·524939	699	10·475061	29
32	502231	628	976872	71	525359	698	474641	28
33	502607	628	976830	71	525778	698	474222	27
34	502984	627	976787	71	526197	697	473803	26
35	503360	626	976745	71	526615	697	473385	25
36	503735	626	976702	71	527033	696	472967	24
37	504110	625	976660	71	527451	696	472549	23
38	504485	625	976617	71	527868	695	472132	22
39	504860	624	976574	71	528285	695	471715	21
40	505234	623	976532	71	528702	694	471298	20
41	9·505608	623	9·976489	71	9·529119	693	10·470881	19
42	505981	622	976446	71	529535	693	470465	18
43	506354	622	976404	71	529950	693	470050	17
44	506727	621	976361	71	530366	692	469634	16
45	507099	620	976318	71	530781	691	469219	15
46	507471	620	976275	71	531196	691	468804	14
47	507843	619	976232	72	531611	690	468389	13
48	508214	619	976189	72	532025	690	467975	12
49	508585	618	976146	72	532439	689	467561	11
50	508956	618	976103	72	532853	689	467147	10
51	9·509326	617	9·976060	72	9·533266	688	10·466734	9
52	509696	616	976017	72	533679	688	466321	8
53	510065	616	975974	72	534092	687	465908	7
54	510434	615	975930	72	534504	687	465496	6
55	510803	615	975887	72	534916	686	465084	5
56	511172	614	975844	72	535328	686	464672	4
57	511540	613	975800	72	535739	685	464261	3
58	511907	613	975757	72	536150	685	463850	2
59	512275	612	975714	72	536561	684	463439	1
60	512642	612	975670	72	536972	684	463028	0
	Cosine		Sine		Cotang.		Tang.	M.

71 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·512642	612	9·975670	73	9·536972	684	10·463028	60
1	513009	611	975627	73	537382	683	462618	59
2	513375	611	975583	73	537792	683	462208	58
3	513741	610	975539	73	538202	682	461798	57
4	514107	609	975496	73	538611	682	461389	56
5	514472	609	975452	73	539020	681	460980	55
6	514837	608	975408	73	539429	681	460571	54
7	515202	608	975365	73	539837	680	460163	53
8	515566	607	975321	73	540245	680	459755	52
9	515930	607	975277	73	540653	679	459347	51
10	516294	606	975233	73	541061	679	458939	50
11	9·516657	605	9·975189	73	9·541468	678	10·458532	49
12	517020	605	975145	73	541875	678	458125	48
13	517382	604	975101	73	542281	677	457719	47
14	517745	604	975057	73	542688	677	457312	46
15	518107	603	975013	73	543094	676	456906	45
16	518468	603	974969	74	543499	676	456501	44
17	518829	602	974925	74	543905	675	456095	43
18	519190	601	974880	74	544310	675	455690	42
19	519551	601	974836	74	544715	674	455285	41
20	519911	600	974792	74	545119	674	454881	40
21	9·520271	600	9·974748	74	9·545524	673	10·454476	39
22	520631	599	974703	74	545928	673	454072	38
23	520990	599	974659	74	546331	672	453669	37
24	521349	598	974614	74	546735	672	453265	36
25	521707	598	974570	74	547138	671	452862	35
26	522066	597	974525	74	547540	671	452460	34
27	522424	596	974481	74	547943	670	452057	33
28	522781	596	974436	74	548345	670	451655	32
29	523138	595	974391	74	548747	669	451253	31
30	523495	595	974347	75	549149	669	450851	30
31	9·523852	594	9·974302	75	9·549550	668	10·450450	29
32	524208	594	974257	75	549951	668	450049	28
33	524564	593	974212	75	550352	667	449648	27
34	524920	593	974167	75	550752	667	449248	26
35	525275	592	974122	75	551152	666	448848	25
36	525630	591	974077	75	551552	666	448448	24
37	525984	591	974032	75	551952	665	448048	23
38	526339	590	973987	75	552351	665	447649	22
39	526693	590	973942	75	552750	665	447250	21
40	527046	589	973897	75	553149	664	446851	20
41	9·527400	589	9·973852	75	9·553548	664	10·446452	19
42	527753	588	973807	75	553946	663	446054	18
43	528105	588	973761	75	554344	663	445656	17
44	528458	587	973716	76	554741	662	445259	16
45	528810	587	973671	76	555139	662	444861	15
46	529161	586	973625	76	555536	661	444464	14
47	529513	586	973580	76	555933	661	444067	13
48	529864	585	973535	76	556329	660	443671	12
49	530215	585	973489	76	556725	660	443275	11
50	530565	584	973444	76	557121	659	442879	10
51	9·530915	584	9·973398	76	9·557517	659	10·442483	9
52	531265	583	973352	76	557913	659	442087	8
53	531614	582	973307	76	558308	658	441692	7
54	531963	582	973261	76	558702	658	441298	6
55	532312	581	973215	76	559097	657	440903	5
56	532661	581	973169	76	559491	657	440509	4
57	533009	580	973124	76	559885	656	440115	3
58	533357	580	973078	76	560279	656	439721	2
59	533704	579	973032	77	560673	655	439327	1
60	534052	578	972986	77	561066	655	438934	0
	Cosine		Sine		Cotang.		Tang.	M.

70 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·534052	578	9·972986	77	9·561066	655	10·438934	60
1	534399	577	972940	77	561459	654	438541	59
2	534745	577	972894	77	561851	654	438149	58
3	535092	577	972848	77	562244	653	437756	57
4	535438	576	972802	77	562636	653	437364	56
5	535783	576	972755	77	563028	653	436972	55
6	536129	575	972709	77	563419	652	436581	54
7	536474	574	972663	77	563811	652	436189	53
8	536818	574	972617	77	564202	651	435798	52
9	537163	573	972570	77	564592	651	435408	51
10	537507	573	972524	77	564983	650	435017	50
11	9·537851	572	9·972478	77	9·565373	650	10·434627	49
12	538194	572	972431	78	565763	649	434237	48
13	538538	571	972385	78	566153	649	433847	47
14	538880	571	972338	78	566542	649	433458	46
15	539223	570	972291	78	566932	648	433068	45
16	539565	570	972245	78	567320	648	432680	44
17	539907	569	972198	78	567709	647	432291	43
18	540249	569	972151	78	568098	647	431902	42
19	540590	568	972105	78	568486	646	431514	41
20	540931	568	972058	78	568873	646	431127	40
21	9·541272	567	9·972011	78	9·569261	645	10·430739	39
22	541613	567	971964	78	569648	645	430352	38
23	541953	566	971917	78	570035	645	429965	37
24	542293	566	971870	78	570422	644	429578	36
25	542632	565	971823	78	570809	644	429191	35
26	542971	565	971776	78	571195	643	428805	34
27	543310	564	971729	79	571581	643	428419	33
28	543649	564	971682	79	571967	642	428033	32
29	543987	563	971635	79	572352	642	427648	31
30	544325	563	971588	79	572738	642	427262	30
31	9·544663	562	9·971540	79	9·573123	641	10·426877	29
32	545000	562	971493	79	573507	641	426493	28
33	545338	561	971446	79	573892	640	426108	27
34	545674	561	971398	79	574276	640	425724	26
35	546011	560	971351	79	574660	639	425340	25
36	546347	560	971303	79	575044	639	424956	24
37	546683	559	971256	79	575427	639	424573	23
38	547019	559	971208	79	575810	638	424190	22
39	547354	558	971161	79	576193	638	423807	21
40	547689	558	971113	79	576576	637	423424	20
41	9·548024	557	9·971066	80	9·576958	637	10·423041	19
42	548359	557	971018	80	577341	636	422659	18
43	548693	556	970970	80	577723	636	422277	17
44	549027	556	970922	80	578104	636	421896	16
45	549360	555	970874	80	578486	635	421514	15
46	549693	555	970827	80	578867	635	421133	14
47	550026	554	970779	80	579248	634	420752	13
48	550359	554	970731	80	579629	634	420371	12
49	550692	553	970683	80	580009	634	419991	11
50	551024	553	970635	80	580389	633	419611	10
51	9·551356	552	9·970586	80	9·580769	633	10·419231	9
52	551687	552	970538	80	581149	632	418851	8
53	552018	552	970490	80	581528	632	418472	7
54	552349	551	970442	80	581907	632	418093	6
55	552680	551	970394	80	582286	631	417714	5
56	553010	550	970345	81	582665	631	417335	4
57	553341	550	970297	81	583043	630	416957	3
58	553670	549	970249	81	583422	630	416578	2
59	554000	549	970200	81	583800	629	416200	1
60	554329	548	970152	81	584177	629	415823	0
	Cosine		Sine		Cotang.		Tang.	M.

69 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·554329	548	9·970152	81	9·584177	629	10·415823	60
1	554658	548	970103	81	584555	629	415445	59
2	554987	547	970055	81	584932	628	415068	58
3	555315	547	970006	81	585309	628	414691	57
4	555643	546	969957	81	585686	627	414314	56
5	555971	546	969909	81	586062	627	413938	55
6	556299	545	969860	81	586439	627	413561	54
7	556626	545	969811	81	586815	626	413185	53
8	556953	544	969762	81	587190	626	412810	52
9	557280	544	969714	81	587566	625	412434	51
10	557606	543	969665	81	587941	625	412059	50
11	9·557932	543	9·969616	82	9·588316	625	10·411684	49
12	558258	543	969567	82	588691	624	411309	48
13	558583	542	969518	82	589066	624	410934	47
14	558909	542	969469	82	589440	623	410560	46
15	559234	541	969420	82	589814	623	410186	45
16	559558	541	969370	82	590188	623	409812	44
17	559883	540	969321	82	590562	622	409438	43
18	560207	540	969272	82	590935	622	409065	42
19	560531	539	969223	82	591308	622	408692	41
20	560855	539	969173	82	591681	621	408319	40
21	9·561178	538	9·969124	82	9·592054	621	10·407946	39
22	561501	538	969075	82	592426	620	407574	38
23	561824	537	969025	82	592798	620	407202	37
24	562146	537	968976	82	593170	619	406830	36
25	562468	536	968926	83	593542	619	406458	35
26	562790	536	968877	83	593914	618	406086	34
27	563112	536	968827	83	594285	618	405715	33
28	563433	535	968777	83	594656	618	405344	32
29	563755	535	968728	83	595027	617	404973	31
30	564075	534	968678	83	595398	617	404602	30
31	9·564396	534	9·968628	83	9·595768	617	10·404232	29
32	564716	533	968578	83	596138	616	403862	28
33	565036	533	968528	83	596508	616	403492	27
34	565356	532	968479	83	596878	616	403122	26
35	565676	532	968429	83	597247	615	402753	25
36	565995	531	968379	83	597616	615	402384	24
37	566314	531	968329	83	597985	615	402015	23
38	566632	531	968278	83	598354	614	401646	22
39	566951	530	968228	84	598722	614	401278	21
40	567269	530	968178	84	599091	613	400909	20
41	9·567587	529	9·968128	84	9·599459	613	10·400541	19
42	567904	529	968078	84	599827	613	400173	18
43	568222	528	968027	84	600194	612	399806	17
44	568539	528	967977	84	600562	612	399438	16
45	568856	528	967927	84	600929	611	399071	15
46	569172	527	967876	84	601296	611	398704	14
47	569488	527	967826	84	601662	611	398338	13
48	569804	526	967775	84	602029	610	397971	12
49	570120	526	967725	84	602395	610	397605	11
50	570435	525	967674	84	602761	610	397239	10
51	9·570751	525	9·967624	84	9·603127	609	10·396873	9
52	571066	524	967573	84	603493	609	396507	8
53	571380	524	967522	85	603858	609	396142	7
54	571695	523	967471	85	604223	608	395777	6
55	572009	523	967421	85	604588	608	395412	5
56	572323	523	967370	85	604953	607	395047	4
57	572636	522	967319	85	605317	607	394683	3
58	572950	522	967268	85	605682	607	394318	2
59	573263	521	967217	85	606046	606	393954	1
60	573575	521	967166	85	606410	606	393590	0
	Cosine		Sine		Cotang.		Tang.	M.

68 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·573575	521	9·967166	85	9·606410	606	10·393590	60
1	573888	520	967115	85	606773	606	393227	59
2	574200	520	967064	85	607137	605	392863	58
3	574512	519	967013	85	607500	605	392500	57
4	574824	519	966961	85	607863	604	392137	56
5	575136	519	966910	85	608225	604	391775	55
6	575447	518	966859	85	608588	604	391412	54
7	575758	518	966808	85	608950	603	391050	53
8	576069	517	966756	86	609312	603	390688	52
9	576379	517	966705	86	609674	603	390326	51
10	576689	516	966653	86	610036	602	389964	50
11	9·576999	516	9·966602	86	9·610397	602	10·389603	49
12	577309	516	966550	86	610759	602	389241	48
13	577618	515	966499	86	611120	601	388880	47
14	577927	515	966447	86	611480	601	388520	46
15	578236	514	966395	86	611841	601	388159	45
16	578545	514	966344	86	612201	600	387799	44
17	578853	513	966292	86	612561	600	387439	43
18	579162	513	966240	86	612921	600	387079	42
19	579470	513	966188	86	613281	599	386719	41
20	579777	512	966136	86	613641	599	386359	40
21	9·580085	512	9·966085	87	9·614000	598	10·386000	39
22	580392	511	966033	87	614359	598	385641	38
23	580699	511	965981	87	614718	598	385282	37
24	581005	511	965928	87	615077	597	384923	36
25	581312	510	965876	87	615435	597	384565	35
26	581618	510	965824	87	615793	597	384207	34
27	581924	509	965772	87	616151	596	383849	33
28	582229	509	965720	87	616509	596	383491	32
29	582535	509	965668	87	616867	596	383133	31
30	582840	508	965615	87	617224	595	382776	30
31	9·583145	508	9·965563	87	9·617582	595	10·382418	29
32	583449	507	965511	87	617939	595	382061	28
33	583754	507	965458	87	618295	594	381705	27
34	584058	506	965406	87	618652	594	381348	26
35	584361	506	965353	88	619008	594	380992	25
36	584665	506	965301	88	619364	593	380636	24
37	584968	505	965248	88	619721	593	380279	23
38	585272	505	965195	88	620076	593	379924	22
39	585574	504	965143	88	620432	592	379568	21
40	585877	504	965090	88	620787	592	379213	20
41	9·586179	503	9·965037	88	9·621142	592	10·378858	19
42	586482	503	964984	88	621497	591	378503	18
43	586783	503	964931	88	621852	591	378148	17
44	587085	502	964879	88	622207	590	377793	16
45	587386	502	964826	88	622561	590	377439	15
46	587688	501	964773	88	622915	590	377085	14
47	587989	501	964719	88	623269	589	376731	13
48	588289	501	964666	89	623623	589	376377	12
49	588590	500	964613	89	623976	589	376024	11
50	588890	500	964560	89	624330	588	375670	10
51	9·589190	499	9·964507	89	9·624683	588	10·375317	9
52	589489	499	964454	89	625036	588	374964	8
53	589789	499	964400	89	625388	587	374612	7
54	590088	498	964347	89	625741	587	374259	6
55	590387	498	964294	89	626093	587	373907	5
56	590686	497	964240	89	626445	586	373555	4
57	590984	497	964187	89	626797	586	373203	3
58	591282	497	964133	89	627149	586	372851	2
59	591580	496	964080	89	627501	585	372499	1
60	591878	496	964026	89	627852	585	372148	0
	Cosine		Sine		Cotang.		Tang.	

67 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·554329	548	9·970152	81	9·584177	629	10·415823	60
1	554658	548	970103	81	584555	629	415445	59
2	554987	547	970055	81	584932	628	415068	58
3	555315	547	970006	81	585309	628	414691	57
4	555643	546	969957	81	585686	627	414314	56
5	555971	546	969909	81	586062	627	413938	55
6	556299	545	969860	81	586439	627	413561	54
7	556626	545	969811	81	586815	626	413185	53
8	556953	544	969762	81	587190	626	412810	52
9	557280	544	969714	81	587566	625	412434	51
10	557606	543	969665	81	587941	625	412059	50
11	9 557932	543	9·969616	82	9·588316	625	10·411684	49
12	558258	543	969567	82	588691	624	411309	48
13	558583	542	969518	82	589066	624	410934	47
14	558909	542	969469	82	589440	623	410560	46
15	559234	541	969420	82	589814	623	410186	45
16	559558	541	969370	82	590188	623	409812	44
17	559883	540	969321	82	590562	622	409438	43
18	560207	540	969272	82	590935	622	409065	42
19	560531	539	969223	82	591308	622	408692	41
20	560855	539	969173	82	591681	621	408319	40
21	9·561178	538	9·969124	82	9·592054	621	10·407946	39
22	561501	538	969075	82	592426	620	407574	38
23	561824	537	969025	82	592798	620	407202	37
24	562146	537	968976	82	593170	619	406829	36
25	562468	536	968926	83	593542	619	406458	35
26	562790	536	968877	83	593914	618	406086	34
27	563112	536	968827	83	594285	618	405715	33
28	563433	535	968777	83	594656	618	405344	32
29	563755	535	968728	83	595027	617	404973	31
30	564075	534	968678	83	595398	617	404602	30
31	9·564396	534	9·968628	83	9·595768	617	10·404232	29
32	564716	533	968578	83	596138	616	403862	28
33	565036	533	968528	83	596508	616	403492	27
34	565356	532	968479	83	596878	616	403122	26
35	565676	532	968429	83	597247	615	402753	25
36	565995	531	968379	83	597616	615	402384	24
37	566314	531	968329	83	597985	615	402015	23
38	566632	531	968278	83	598354	614	401646	22
39	566951	530	968228	84	598722	614	401278	21
40	567269	530	968178	84	599091	613	400909	20
41	9·567587	529	9·968128	84	9·599459	613	10·400541	19
42	567904	529	968078	84	599827	613	400173	18
43	568222	528	968027	84	600194	612	399806	17
44	568539	528	967977	84	600562	612	399438	16
45	568856	528	967927	84	600929	611	399071	15
46	569172	527	967876	84	601296	611	398704	14
47	569488	527	967826	84	601662	611	398338	13
48	569804	526	967775	84	602029	610	397971	12
49	570120	526	967725	84	602395	610	397605	11
50	570435	525	967674	84	602761	610	397239	10
51	9·570751	525	9·967624	84	9·603127	609	10·396873	9
52	571066	524	967573	84	603493	609	396507	8
53	571380	524	967522	85	603858	609	396142	7
54	571695	523	967471	85	604223	608	395777	6
55	572009	523	967421	85	604588	608	395412	5
56	572323	523	967370	85	604953	607	395047	4
57	572636	522	967319	85	605317	607	394683	3
58	572950	522	967268	85	605682	607	394318	2
59	573263	521	967217	85	606046	606	393954	1
60	573575	521	967166	85	606410	606	393590	0
	Cosine		Sine		Cotang.		Tang.	M.

68 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·609313	473	9·960730	94	9·648583	566	10·351417	60
1	609597	472	960674	94	648923	566	351077	59
2	609880	472	960618	94	649263	566	350737	58
3	610164	472	960561	94	649602	566	350398	57
4	610447	471	960505	94	649942	565	350058	56
5	610729	471	960448	94	650281	565	349719	55
6	611012	470	960392	94	650620	565	349380	54
7	611294	470	960335	94	650959	564	349041	53
8	611576	470	960279	94	651297	564	348703	52
9	611858	469	960222	94	651636	564	348364	51
10	612140	469	960165	94	651974	563	348026	50
11	9·612421	469	9·960109	95	9·652312	563	10·347688	49
12	612702	468	960052	95	652650	563	347350	48
13	612983	468	959995	95	652988	563	347012	47
14	613264	467	959938	95	653326	562	346674	46
15	613545	467	959882	95	653663	562	346337	45
16	613825	467	959825	95	654000	562	346000	44
17	614105	466	959768	95	654337	561	345663	43
18	614385	466	959711	95	654674	561	345326	42
19	614665	466	959654	95	655011	561	344989	41
20	614944	465	959596	95	655348	561	344652	40
21	9·615223	465	9·959539	95	9·655684	560	10·344316	39
22	615502	465	959482	95	656020	560	343980	38
23	615781	464	959425	95	656356	560	343644	37
24	616060	464	959368	95	656692	559	343308	36
25	616338	464	959310	96	657028	559	342972	35
26	616616	463	959253	96	657364	559	342636	34
27	616894	463	959195	96	657699	559	342301	33
28	617172	462	959138	96	658034	558	341966	32
29	617450	462	959081	96	658369	558	341631	31
30	617727	462	959023	96	658704	558	341296	30
31	9·618004	461	9·958965	96	9·659039	558	10·340961	29
32	618281	461	958908	96	659373	557	340627	28
33	618558	461	958850	96	659708	557	340292	27
34	618834	460	958792	96	660042	557	339958	26
35	619110	460	958734	96	660376	557	339624	25
36	619386	460	958677	96	660710	556	339290	24
37	619662	459	958619	96	661043	556	338957	23
38	619938	459	958561	96	661377	556	338623	22
39	620213	459	958503	97	661710	555	338290	21
40	620488	458	958445	97	662043	555	337957	20
41	9·620763	458	9·958387	97	9·662376	555	10·337624	19
42	621038	457	958329	97	662709	554	337291	18
43	621313	457	958271	97	663042	554	336958	17
44	621587	457	958213	97	663375	554	336625	16
45	621861	456	958154	97	663707	554	336293	15
46	622135	456	958096	97	664039	553	335961	14
47	622409	456	958038	97	664371	553	335629	13
48	622682	455	957979	97	664703	553	335297	12
49	622956	455	957921	97	665035	553	334965	11
50	623229	455	957863	97	665366	552	334634	10
51	9·623502	454	9·957804	97	9·665697	552	10·334303	9
52	623774	454	957746	98	666029	552	333971	8
53	624047	454	957687	98	666360	551	333640	7
54	624319	453	957628	98	666691	551	333309	6
55	624591	453	957570	98	667021	551	332979	5
56	624863	453	957511	98	667352	551	332648	4
57	625135	452	957452	98	667682	550	332318	3
58	625406	452	957393	98	668013	550	331987	2
59	625677	452	957335	98	668343	550	331657	1
60	625948	451	957276	98	668672	550	331328	0
	Cosine		Sine		Cotang.		Tang.	M.

65 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·625948	451	9·957276	98	9·668673	550	10·331327	60
1	626219	451	957217	98	669002	549	330998	59
2	626490	451	957158	98	669332	549	330668	58
3	626760	450	957099	98	669661	549	330339	57
4	627030	450	957040	98	669991	548	330009	56
5	627300	450	956981	98	670320	548	329680	55
6	627570	449	956921	99	670649	548	329351	54
7	627840	449	956862	99	670977	548	329023	53
8	628109	449	956803	99	671306	547	328694	52
9	628378	448	956744	99	671634	547	328366	51
10	628647	448	956684	99	671963	547	328037	50
11	9·628916	447	9·956625	99	9·672291	547	10·327709	49
12	629185	447	956566	99	672619	546	327381	48
13	629453	447	956506	99	672947	546	327053	47
14	629721	446	956447	99	673274	546	326726	46
15	629989	446	956387	99	673602	546	326398	45
16	630257	446	956327	99	673929	545	326071	44
17	630524	446	956268	99	674257	545	325743	43
18	630792	445	956208	100	674584	545	325416	42
19	631059	445	956148	100	674910	544	325090	41
20	631326	445	956089	100	675237	544	324763	40
21	9·631593	444	9·956029	100	9·675564	544	10·324436	39
22	631859	444	955969	100	675890	544	324110	38
23	632125	444	955909	100	676216	543	323784	37
24	632392	443	955849	100	676543	543	323457	36
25	632658	443	955789	100	676869	543	323131	35
26	632923	443	955729	100	677194	543	322806	34
27	633189	442	955669	100	677520	542	322480	33
28	633454	442	955609	100	677846	542	322154	32
29	633719	442	955548	100	678171	542	321829	31
30	633984	441	955488	100	678496	542	321504	30
31	9·634249	441	9·955428	101	9·678821	541	10·321179	29
32	634514	440	955368	101	679146	541	320854	28
33	634778	440	955307	101	679471	541	320529	27
34	635042	440	955247	101	679795	541	320205	26
35	635306	439	955186	101	680120	540	319880	25
36	635570	439	955126	101	680444	540	319556	24
37	635834	439	955065	101	680768	540	319232	23
38	636097	438	955005	101	681092	540	318908	22
39	636360	438	954944	101	681416	539	318584	21
40	636623	438	954883	101	681740	539	318260	20
41	9·636886	437	9·954823	101	9·682063	539	10·317937	19
42	637148	437	954762	101	682387	539	317613	18
43	637411	437	954701	101	682710	538	317290	17
44	637673	437	954640	101	683033	538	316967	16
45	637935	436	954579	101	683356	538	316644	15
46	638197	436	954518	102	683679	538	316321	14
47	638458	436	954457	102	684001	537	315999	13
48	638720	435	954396	102	684324	537	315676	12
49	638981	435	954335	102	684646	537	315354	11
50	639242	435	954274	102	684968	537	315032	10
51	9·639503	434	9·954213	102	9·685290	536	10·314710	9
52	639764	434	954152	102	685612	536	314388	8
53	640024	434	954090	102	685934	536	314066	7
54	640284	433	954029	102	686255	536	313745	6
55	640544	433	953968	102	686577	535	313423	5
56	640804	433	953906	102	686898	535	313102	4
57	641064	432	953845	102	687219	535	312781	3
58	641324	432	953783	102	687540	535	312460	2
59	641584	432	953722	103	687861	534	3[illegible]	
60	641842	431	953660	103	688182	534	[illegible]	
	Cosin		Sine		Cotang.			

64 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·641842	431	9·953660	103	9·688182	534	10·311818	60
1	642101	431	953599	103	688502	534	311498	59
2	642360	421	953537	103	688823	534	311177	58
3	642618	430	953475	103	689143	533	310857	57
4	642877	430	953413	103	689463	533	310537	56
5	643135	430	953352	103	689783	533	310217	55
6	643393	430	953290	103	690103	533	309897	54
7	643650	429	953228	103	690423	533	309577	53
8	643908	429	953166	103	690742	532	309258	52
9	644165	429	953104	103	691062	532	308938	51
10	644423	428	953042	103	691381	532	308619	50
11	9·644680	428	9·952980	104	9·691700	531	10·308300	49
12	644936	428	952918	104	692019	531	307981	48
13	645193	427	952855	104	692338	531	307662	47
14	645450	427	952793	104	692656	531	307344	46
15	645706	427	952731	104	692975	531	307025	45
16	645962	426	952669	104	693293	530	306707	44
17	646218	426	952606	104	693612	530	306388	43
18	646474	426	952544	104	693930	530	306070	42
19	646729	425	952481	104	694248	530	305752	41
20	646984	425	952419	104	694566	529	305434	40
21	9·647240	425	9·952356	104	9·694883	529	10·305117	39
22	647494	424	952294	104	695201	529	304799	38
23	647749	424	952231	104	695518	529	304482	37
24	648004	424	952168	105	695836	529	304164	36
25	648258	424	952106	105	696153	528	303847	35
26	648512	423	952043	105	696470	528	303530	34
27	648766	423	951980	105	696787	528	303213	33
28	649020	423	951917	105	697103	528	302897	32
29	649274	422	951854	105	697420	527	302580	31
30	649527	422	951791	105	697736	527	302264	30
31	9·649781	422	9·951728	105	9·698053	527	10·301947	29
32	650034	422	951665	105	698369	527	301631	28
33	650287	421	951602	105	698685	526	301315	27
34	650539	421	951539	105	699001	526	300999	26
35	650792	421	951476	105	699316	526	300684	25
36	651044	420	951412	105	699632	526	300368	24
37	651297	420	951349	106	699947	526	300053	23
38	651549	420	951286	106	700263	525	299737	22
39	651800	419	951222	106	700578	525	299422	21
40	652052	419	951159	106	700893	525	299107	20
41	9·652304	419	9·951096	106	9·701208	524	10·298792	19
42	652555	418	951032	106	701523	524	298477	18
43	652806	418	950968	106	701837	524	298163	17
44	653057	418	950905	106	702152	524	297848	16
45	653308	418	950841	106	702466	524	297534	15
46	653558	417	950778	106	702780	523	297220	14
47	653808	417	950714	106	703095	523	296905	13
48	654059	417	950650	106	703409	523	296591	12
49	654309	416	950586	106	703723	523	296277	11
50	654558	416	950522	107	704036	522	295964	10
51	654808	416	9·950458	107	9·704350	522	10·295650	9
52	655058	416	950394	107	704663	522	295337	8
53	655307	415	950330	107	704977	522	295023	7
54	655556	415	950266	107	705290	522	294710	6
55	655805	415	950202	107	705603	521	294397	5
56	656054	414	950138	107	705916	521	294084	4
57	656302	414	950074	107	706228	521	293772	3
58	656551	414	950010	107	706541	521	293459	2
59	656799	413	949945	107	706854	521	293146	1
60	657047	413	949881	107	707166	520	292834	0
	Cosine		Sine		Cotang.		Tang.	M.

63 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·657047	413	9·949881	107	9·707166	520	10·292834	60
1	657295	413	949816	107	707478	520	292522	59
2	657542	412	949752	107	707790	520	292210	58
3	657790	412	949688	108	708102	520	291898	57
4	658037	412	949623	108	708414	519	291586	56
5	658284	412	949558	108	708726	519	291274	55
6	658531	411	949494	108	709037	519	290963	54
7	658778	411	949429	108	709349	519	290651	53
8	659025	411	949364	108	709660	519	290340	52
9	659271	410	949300	108	709971	518	290029	51
10	659517	410	949235	108	710282	518	289718	50
11	9·659763	410	9·949170	108	9·710593	518	10·289407	49
12	660009	409	949105	108	710904	518	289096	48
13	660255	409	949040	108	711215	518	288785	47
14	660501	409	948975	108	711525	517	288475	46
15	660746	409	948910	108	711836	517	288164	45
16	660991	408	948845	108	712146	517	287854	44
17	661236	408	948780	109	712456	517	287544	43
18	661481	408	948715	109	712766	516	287234	42
19	661726	407	948650	109	713076	516	286924	41
20	661970	407	948584	109	713386	516	286614	40
21	9·662214	407	9·948519	109	9·713696	516	10·286304	39
22	662459	407	948454	109	714005	516	285995	38
23	662703	406	948388	109	714314	515	285686	37
24	662946	406	948323	109	714624	515	285376	36
25	663190	406	948257	109	714933	515	285067	35
26	663433	405	948192	109	715242	515	284758	34
27	663677	405	948126	109	715551	514	284449	33
28	663920	405	948060	109	715860	514	284140	32
29	664163	405	947995	110	716168	514	283832	31
30	664406	404	947929	110	716477	514	283523	30
31	9·664648	404	9·947863	110	9·716785	514	10·283215	29
32	664891	404	947797	110	717093	513	282907	28
33	665133	403	947731	110	717401	513	282599	27
34	665375	403	947665	110	717709	513	282291	26
35	665617	403	947600	110	718017	513	281983	25
36	665859	402	947533	110	718325	513	281675	24
37	666100	402	947467	110	718633	512	281367	23
38	666342	402	947401	110	718940	512	281060	22
39	666583	402	947335	110	719248	512	280752	21
40	666824	401	947269	110	719555	512	280445	20
41	9·667065	401	9·947203	110	9·719862	512	10·280138	19
42	667305	401	947136	111	720169	511	279831	18
43	667546	401	947070	111	720476	511	279524	17
44	667786	400	947004	111	720783	511	279217	16
45	668027	400	946937	111	721089	511	278911	15
46	668267	400	946871	111	721396	511	278604	14
47	668506	399	946804	111	721702	510	278298	13
48	668746	399	946738	111	722009	510	277991	12
49	668986	399	946671	111	722315	510	277685	11
50	669225	399	946604	111	722621	510	277379	10
51	9·669464	398	9·946538	111	9·722927	510	10·277073	9
52	669703	398	946471	111	723232	509	276768	8
53	669942	398	946404	111	723538	509	276462	7
54	670181	397	946337	111	723844	509	276156	6
55	670419	397	946270	112	724149	509	275851	5
56	670658	397	946203	112	724454	509	275546	4
57	670896	397	946136	112	724759	508	275241	3
58	671134	396	946069	112	725065	508	274935	2
59	671372	396	946002	112	725369	508	274631	1
60	671609	396	945935	112	725674	508	274326	0
	Cosine		Sine		Cotang.		Tang.	M.

62 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·671609	396	9·945935	112	9·725674	508	10·274326	60
1	671847	395	945868	112	725979	508	274021	59
2	672084	395	945800	112	726284	507	273716	58
3	672321	395	945733	112	726588	507	273412	57
4	672558	395	945666	112	726892	507	273108	56
5	672795	394	945598	112	727197	507	272803	55
6	673032	394	945531	112	727501	507	272499	54
7	673268	394	945464	113	727805	506	272195	53
8	673505	394	945396	113	728109	506	271891	52
9	673741	393	945328	113	728412	506	271588	51
10	673977	393	945261	113	728716	506	271284	50
11	9·674213	393	9·945193	113	9·729020	506	10·270980	49
12	674448	392	945125	113	729323	505	270677	48
13	674684	392	945058	113	729626	505	270374	47
14	674919	392	944990	113	729929	505	270071	46
15	675155	392	944922	113	730233	505	269767	45
16	675390	391	944854	113	730535	505	269465	44
17	675624	391	944786	113	730838	504	269162	43
18	675859	391	944718	113	731141	504	268859	42
19	676094	391	944650	113	731444	504	268556	41
20	676328	390	944582	114	731746	504	268254	40
21	9·676562	390	9·944514	114	9·732048	504	10·267952	39
22	676796	390	944446	114	732351	503	267649	38
23	677030	390	944377	114	732653	503	267347	37
24	677264	389	944309	114	732955	503	267045	36
25	677498	389	944241	114	733257	503	266743	35
26	677731	389	944172	114	733558	503	266442	34
27	677964	388	944104	114	733860	502	266140	33
28	678197	388	944036	114	734162	502	265838	32
29	678430	388	943967	114	734463	502	265537	31
30	678663	388	943899	114	734764	502	265236	30
31	9·678895	387	9·943830	114	9·735066	502	10·264934	29
32	679128	387	943761	114	735367	502	264633	28
33	679360	387	943693	115	735668	501	264332	27
34	679592	387	943624	115	735969	501	264031	26
35	679824	386	943555	115	736269	501	263731	25
36	680056	386	943486	115	736570	501	263430	24
37	680288	386	943417	115	736871	501	263129	23
38	680519	385	943348	115	737171	500	262829	22
39	680750	385	943279	115	737471	500	262529	21
40	680982	385	943210	115	737771	500	262229	20
41	9·681213	385	9·943141	115	9·738071	500	10·261929	19
42	681443	384	943072	115	438371	500	261629	18
43	681674	384	943003	115	738671	499	261329	17
44	681905	384	942934	115	738971	499	261029	16
45	682135	384	942864	115	739271	499	260729	15
46	682365	383	942795	116	739570	499	260430	14
47	682595	383	942726	116	739870	499	260130	13
48	682825	383	942656	116	740169	499	259831	12
49	683055	383	942587	116	740468	498	259532	11
50	683284	382	942517	116	740767	498	259233	10
51	9·683514	382	9·942448	116	9·741066	498	10·258934	9
52	683743	382	942378	116	741365	498	258635	8
53	683972	382	942308	116	741664	498	258336	7
54	684201	381	942239	116	741962	497	258038	6
55	684430	381	942169	116	742261	497	257739	5
56	684658	381	942099	116	742559	497	257441	4
57	684887	380	942029	116	742858	497	257142	3
58	685115	380	941959	116	743156	497	256844	2
59	685343	380	941889	117	743454	497	256546	1
60	685571	380	941819	117	743752	496	256248	0
	Cosine		Sine		Cotang.		Tang.	M.

61 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang	
0	9·685571	380	9·941819	117	9·743752	496	10·256248	60
1	685799	379	941749	117	744050	496	255950	59
2	686027	379	941679	117	744348	496	255652	58
3	686254	379	941609	117	744645	496	255355	57
4	686482	379	941539	117	744943	496	255057	56
5	686709	378	941469	117	745240	496	254760	55
6	686936	378	941398	117	745538	495	254462	54
7	687163	378	941328	117	745835	495	254165	53
8	687389	378	941258	117	746132	495	253868	52
9	687616	377	941187	117	746429	495	253571	51
10	687843	377	941117	117	746726	495	253274	50
11	9·688069	377	9·941046	118	9·747023	494	10·252977	49
12	688295	377	940975	118	747319	494	252681	48
13	688521	376	940905	118	747616	494	252384	47
14	688747	376	940834	118	747913	494	252087	46
15	688972	376	940763	118	748209	494	251791	45
16	689198	376	940693	118	748505	493	251495	44
17	689423	375	940622	118	748801	493	251199	43
18	689648	375	940551	118	749097	493	250903	42
19	689873	375	940480	118	749393	493	250607	41
20	690098	375	940409	118	749689	493	250311	40
21	9·690323	374	9·940338	118	9·749985	493	10·250015	39
22	690548	374	940267	118	750281	492	249719	38
23	690772	374	940196	118	750576	492	249424	37
24	690996	374	940125	119	750872	492	249128	36
25	691220	373	940054	119	751167	492	248833	35
26	691444	373	939982	119	751462	492	248538	34
27	691668	373	939911	119	751757	492	248243	33
28	691892	373	939840	119	752052	491	247948	32
29	692115	372	939768	119	752347	491	247653	31
30	692339	372	939697	119	752642	491	247358	30
31	9·692562	372	9·939625	119	9·752937	491	10·247063	29
32	692785	371	939554	119	753231	491	246769	28
33	693008	371	939482	119	753526	491	246474	27
34	693231	371	939410	119	753820	490	246180	26
35	693453	371	939339	119	754115	490	245885	25
36	693676	370	939267	120	754409	490	245591	24
37	693898	370	939195	120	754703	490	245297	23
38	694120	370	939123	120	754997	490	245003	22
39	694342	370	939052	120	755291	490	244709	21
40	694564	369	938980	120	755585	489	244415	20
41	9·694786	369	9·938908	120	9·755878	489	10·244122	19
42	695007	369	938836	120	756172	489	243828	18
43	695229	369	938763	120	756465	489	243535	17
44	695450	368	938691	120	756759	489	243241	16
45	695671	368	938619	120	757052	489	242948	15
46	695892	368	938547	120	757345	488	242655	14
47	696113	368	938475	120	757638	488	242362	13
48	696334	367	938402	121	757931	488	242069	12
49	696554	367	938330	121	758224	488	241776	11
50	696775	367	938258	121	758517	488	241483	10
51	9·696995	367	9·938185	121	9·758810	488	10·241190	9
52	697215	366	938113	121	759102	487	240898	8
53	697435	366	938040	121	759395	487	240605	7
54	697654	366	937967	121	759687	487	240313	6
55	697874	366	937895	121	759979	487	240021	5
56	698094	365	937822	121	760272	487	239728	4
57	698313	365	937749	121	760564	487	239436	3
58	698532	365	937676	121	760856	486	239144	2
59	698751	365	937604	121	761148	486	238852	
60	698970	364	937531	121	761439	486	238561	
	Cosine				Cotang.		Tang	

Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·698970	364	9·937531	121	9·761439	486	10·238561	60
1	699189	364	937458	122	761731	486	238269	59
2	699407	364	937385	122	762023	486	237977	58
3	699626	364	937312	122	762314	486	237686	57
4	699844	363	937238	122	762606	485	237394	56
5	700062	363	937165	122	762897	485	237103	55
6	700280	363	937092	122	763188	485	236812	54
7	700498	363	937019	122	763479	485	236521	53
8	700716	363	936946	122	763770	485	236230	52
9	700933	362	936872	122	764061	485	235939	51
10	701151	362	936799	122	764352	484	235648	50
11	9·701368	362	9·936725	122	9·764643	484	10·235357	49
12	701585	362	936652	123	764933	484	235067	48
13	701802	361	936578	123	765224	484	234776	47
14	702019	361	936505	123	765514	484	234486	46
15	702236	361	936431	123	765805	484	234195	45
16	702452	361	936357	123	766095	484	233905	44
17	702669	360	936284	123	766385	483	233615	43
18	702885	360	936210	123	766675	483	233325	42
19	703101	360	936136	123	766965	483	233035	41
20	703317	360	936062	123	767255	483	232745	40
21	9·703533	359	9·935988	123	9·767545	483	10·232455	39
22	703749	359	935914	123	767834	483	232166	38
23	703964	359	935840	123	768124	482	231876	37
24	704179	359	935766	124	768413	482	231587	36
25	704395	359	935692	124	768703	482	231297	35
26	704610	358	935618	124	768992	482	231008	34
27	704825	358	935543	124	769281	482	230719	33
28	705040	358	935469	124	769570	482	230430	32
29	705254	358	935395	124	769860	481	230140	31
30	705469	357	935320	124	770148	481	229852	30
31	9·705683	357	9·935246	124	9·770437	481	10·229563	29
32	705898	357	935171	124	770726	481	229274	28
33	706112	357	935097	124	771015	481	228985	27
34	706326	356	935022	124	771303	481	228697	26
35	706539	356	934948	124	771592	481	228408	25
36	706753	356	934873	124	771880	480	228120	24
37	706967	356	934798	125	772168	480	227832	23
38	707180	355	934723	125	772457	480	227543	22
39	707393	355	934649	125	772745	480	227255	21
40	707606	355	934574	125	773033	480	226967	20
41	9·707819	355	9·934499	125	9·773321	480	10·226679	19
42	708032	354	934424	125	773608	479	226392	18
43	708245	354	934349	125	773896	479	226104	17
44	708458	354	934274	125	774184	479	225816	16
45	708670	354	934199	125	774471	479	225529	15
46	708882	353	934123	125	774759	479	225241	14
47	709094	353	934048	125	775046	479	224954	13
48	709306	353	933973	125	775333	479	224667	12
49	709518	353	933898	126	775621	478	224379	11
50	709730	353	933822	126	775908	478	224092	10
51	9·709941	352	9·933747	126	9·776195	478	10·223805	9
52	710153	352	933671	126	776482	478	223518	8
53	710364	352	933596	126	776769	478	223231	7
54	710575	352	933520	126	777055	478	222945	6
55	710786	351	933445	126	777342	478	222658	5
56	710997	351	933369	126	777628	477	222372	4
57	711208	351	933293	126	777915	477	222085	3
58	711419	351	933217	126	778201	477	221799	2
59	711629	350	933141	126	778487	477	221512	1
60	711839	350	933066	126	778774	477	221226	0
	Cosine		Sine		Cotang.		Tang.	M.

59 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·711839	350	9·933066	126	9·778774	477	10·221226	60
1	712050	350	932990	127	779060	477	220940	59
2	712260	350	932914	127	779346	476	220654	58
3	712469	349	932838	127	779632	476	220368	57
4	712679	349	932762	127	779918	476	220082	56
5	712889	349	932685	127	780203	476	219797	55
6	713098	349	932609	127	780489	476	219511	54
7	713308	349	932533	127	780775	476	219225	53
8	713517	348	932457	127	781060	476	218940	52
9	713726	348	932380	127	781346	475	218654	51
10	713935	348	932304	127	781631	475	218369	50
11	9·714144	348	9·932228	127	9·781916	475	10·218084	49
12	714352	347	932151	127	782201	475	217799	48
13	714561	347	932075	128	782486	475	217514	47
14	714769	347	931998	128	782771	475	217229	46
15	714978	347	931921	128	783056	475	216944	45
16	715186	347	931845	128	783341	475	216659	44
17	715394	346	931768	128	783626	474	216374	43
18	715602	346	931691	128	783910	474	216090	42
19	715809	346	931614	128	784195	474	215805	41
20	716017	346	931537	128	784479	474	215521	40
21	9·716224	345	9·931460	128	9·784764	474	10·215236	39
22	716432	345	931383	128	785048	474	214952	38
23	716639	345	931306	128	785332	473	214668	37
24	716846	345	931229	129	785616	473	214384	36
25	717053	345	931152	129	785900	473	214100	35
26	717259	344	931075	129	786184	473	213816	34
27	717466	344	930998	129	786468	473	213532	33
28	717673	344	930921	129	786752	473	213248	32
29	717879	344	930843	129	787036	473	212964	31
30	718085	343	930766	129	787319	472	212681	30
31	9·718291	343	9·930688	129	9·787603	472	10·212397	29
32	718497	343	930611	129	787886	472	212114	28
33	718703	343	930533	129	788170	472	211830	27
34	718909	343	930456	129	788453	472	211547	26
35	719114	342	930378	129	788736	472	211264	25
36	719320	342	930300	130	789019	472	210981	24
37	719525	342	930223	130	789302	471	210698	23
38	719730	342	930145	130	789585	471	210415	22
39	719935	341	930067	130	789868	471	210132	21
40	720140	341	929989	130	790151	471	209849	20
41	9·720345	341	9·929911	130	9·790433	471	10·209567	19
42	720549	341	929833	130	790716	471	209284	18
43	720754	340	929755	130	790999	471	209001	17
44	720958	340	929677	130	791281	471	208719	16
45	721162	340	929599	130	791563	470	208437	15
46	721366	340	929521	130	791846	470	208154	14
47	721570	340	929442	130	792128	470	207872	13
48	721774	339	929364	131	792410	470	207590	12
49	721978	339	929286	131	792692	470	207308	11
50	722181	339	929207	131	792974	470	207026	10
51	9·722385	339	9·929129	131	9·793256	470	10·206744	9
52	722588	339	929050	131	793538	469	206462	8
53	722791	338	928972	131	793819	469	206181	7
54	722994	338	928893	131	794101	469	205899	6
55	723197	338	928815	131	794383	469	205617	5
56	723400	338	928736	131	794664	469	205336	4
57	723603	337	928657	131	794945	469	205055	3
58	723805	337	928578	131	795227	469	204773	2
59	724007	337	928499	131	795508	468	204492	1
60	724210	337	928420	131	795789	468	204211	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·698970	364	9·937531	121	9·761439	486	10·238561	60
1	699189	364	937458	122	761731	486	238269	59
2	699407	364	937385	122	762023	486	237977	58
3	699626	364	937312	122	762314	486	237686	57
4	699844	363	937238	122	762606	485	237394	56
5	700062	363	937165	122	762897	485	237103	55
6	700280	363	937092	122	763188	485	236812	54
7	700498	363	937019	122	763479	485	236521	53
8	700716	363	936946	122	763770	485	236230	52
9	700933	362	936872	122	764061	485	235939	51
10	701151	362	936799	122	764352	484	235648	50
11	9·701368	362	9·936725	122	9·764643	484	10·235357	49
12	701585	362	936652	123	764933	484	235067	48
13	701802	361	936578	123	765224	484	234776	47
14	702019	361	936505	123	765514	484	234486	46
15	702236	361	936431	123	765805	484	234195	45
16	702452	361	936357	123	766095	484	233905	44
17	702669	360	936284	123	766385	483	233615	43
18	702885	360	936210	123	766675	483	233325	42
19	703101	360	936136	123	766965	483	233035	41
20	703317	360	936062	123	767255	483	232745	40
21	9·703533	359	9·935988	123	9·767545	483	10·232455	39
22	703749	359	935914	123	767834	483	232166	38
23	703964	359	935840	123	768124	482	231876	37
24	704179	359	935766	124	768413	482	231587	36
25	704395	359	935692	124	768703	482	231297	35
26	704610	358	935618	124	768992	482	231008	34
27	704825	358	935543	124	769281	482	230719	33
28	705040	358	935469	124	769570	482	230430	32
29	705254	358	935395	124	769860	481	230140	31
30	705469	357	935320	124	770148	481	229852	30
31	9·705683	357	9·935246	124	9·770437	481	10·229563	29
32	705898	357	935171	124	770726	481	229274	28
33	706112	357	935097	124	771015	481	228985	27
34	706326	356	935022	124	771303	481	228697	26
35	706539	356	934948	124	771592	481	228408	25
36	706753	356	934873	124	771880	480	228120	24
37	706967	356	934798	125	772168	480	227832	23
38	707180	355	934723	125	772457	480	227543	22
39	707393	355	934649	125	772745	480	227255	21
40	707606	355	934574	125	773033	480	226967	20
41	9·707819	355	9·934499	125	9·773321	480	10·226679	19
42	708032	354	934424	125	773608	479	226392	18
43	708245	354	934349	125	773896	479	226104	17
44	708458	354	934274	125	774184	479	225816	16
45	708670	354	934199	125	774471	479	225529	15
46	708882	353	934123	125	774759	479	225241	14
47	709094	353	934048	125	775046	479	224954	13
48	709306	353	933973	125	775333	479	224667	12
49	709518	353	933898	126	775621	478	224379	11
50	709730	353	933822	126	775908	478	224092	10
51	9·709941	352	9·933747	126	9·776195	478	10·223805	9
52	710153	352	933671	126	776482	478	223518	8
53	710364	352	933596	126	776769	478	223231	7
54	710575	352	933520	126	777055	478	222945	6
55	710786	351	933445	126	777342	478	222658	5
56	710997	351	933369	126	777628	477	222372	4
57	711208	351	933293	126	777915	477	222085	3
58	711419	351	933217	126	778201	477	221799	2
59	711629	350	933141	126	778487	477	221512	1
60	711839	350	933066	126	778774	477	221226	0
	Cosine		Sine		Cotang.		Tang.	M.

59 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·711839	350	9·933066	126	9·778774	477	10·221226	60
1	712050	350	932990	127	779060	477	220940	59
2	712260	350	932914	127	779346	476	220654	58
3	712469	349	932838	127	779632	476	220368	57
4	712679	349	932762	127	779918	476	220082	56
5	712889	349	932685	127	780203	476	219797	55
6	713098	349	932609	127	780489	476	219511	54
7	713308	349	932533	127	780775	476	219225	53
8	713517	348	932457	127	781060	476	218940	52
9	713726	348	932380	127	781346	475	218654	51
10	713935	348	932304	127	781631	475	218369	50
11	9·714144	348	9·932228	127	9·781916	475	10·218084	49
12	714352	347	932151	127	782201	475	217799	48
13	714561	347	932075	128	782486	475	217514	47
14	714769	347	931998	128	782771	475	217229	46
15	714978	347	931921	128	783056	475	216944	45
16	715186	347	931845	128	783341	475	216659	44
17	715394	346	931768	128	783626	474	216374	43
18	715602	346	931691	128	783910	474	216090	42
19	715809	346	931614	128	784195	474	215805	41
20	716017	346	931537	128	784479	474	215521	40
21	9·716224	345	9·931460	128	9·784764	474	10·215236	39
22	716432	345	931383	128	785048	474	214952	38
23	716639	345	931306	128	785332	473	214668	37
24	716846	345	931229	129	785616	473	214384	36
25	717053	345	931152	129	785900	473	214100	35
26	717259	344	931075	129	786184	473	213816	34
27	717466	344	930998	129	786468	473	213532	33
28	717673	344	930921	129	786752	473	213248	32
29	717879	344	930843	129	787036	473	212964	31
30	718085	343	930766	129	787319	472	212681	30
31	9·718291	343	9·930688	129	9·787603	472	10·212397	29
32	718497	343	930611	129	787886	472	212114	28
33	718703	343	930533	129	788170	472	211830	27
34	718909	343	930456	129	788453	472	211547	26
35	719114	342	930378	129	788736	472	211264	25
36	719320	342	930300	130	789019	472	210981	24
37	719525	342	930223	130	789302	471	210698	23
38	719730	342	930145	130	789585	471	210415	22
39	719935	341	930067	130	789868	471	210132	21
40	720140	341	929989	130	790151	471	209849	20
41	9·720345	341	9·929911	130	9·790433	471	10·209567	19
42	720549	341	929833	130	790716	471	209284	18
43	720754	340	929755	130	790999	471	209001	17
44	720958	340	929677	130	791281	471	208719	16
45	721162	340	929599	130	791563	470	208437	15
46	721366	340	929521	130	791846	470	208154	14
47	721570	340	929442	130	792128	470	207872	13
48	721774	339	929364	131	792410	470	207590	12
49	721978	339	929286	131	792692	470	207308	11
50	722181	339	929207	131	792974	470	207026	10
51	9·722385	339	9·929129	131	9·793256	470	10·206744	9
52	722588	339	929050	131	793538	469	206462	8
53	722791	338	928972	131	793819	469	206181	7
54	722994	338	928893	131	794101	469	205899	6
55	723197	338	928815	131	794383	469	205617	5
56	723400	338	928736	131	794664	469	205336	4
57	723603	337	928657	131	794945	469	205055	3
58	723805	337	928578	131	795227	469	204773	2
59	724007	337	928499	131	795508	468	204492	1
60	724210	337	928420	131	795789	468	204211	0
	Cosine		Sine		Cotang.		Tang.	M.

58 Degrees.

M.	Sine	D.	Cosine	D.	Targ.	D.	Cotang.	'
0	9·747562	312	9·918574	142	9·828987	454	10·171013	60
1	747749	312	918489	142	829260	454	170740	59
2	747936	312	918404	142	829532	454	170468	58
3	748123	311	918318	142	829805	454	170195	57
4	748310	311	918233	142	830077	454	169923	56
5	748497	311	918147	142	830349	453	169651	55
6	748683	311	918062	142	830621	453	169379	54
7	748870	311	917976	143	830893	453	169107	53
8	749056	310	917891	143	831165	453	168835	52
9	749243	310	917805	143	831437	453	168563	51
10	749429	310	917719	143	831709	453	168291	50
11	9·749615	310	9·917634	143	9·831981	453	10·168019	49
12	749801	310	917548	143	832253	453	167747	48
13	749987	309	917462	143	832525	453	167475	47
14	750172	309	917376	143	832796	453	167204	46
15	750358	309	917290	143	833068	452	166932	45
16	750543	309	917204	143	833339	452	166661	44
17	750729	309	917118	144	833611	452	166389	43
18	750914	308	917032	144	833882	452	166118	42
19	751099	308	916946	144	834154	452	165846	41
20	751284	308	916859	144	834425	452	165575	40
21	9·751469	308	9·916773	144	9·834696	452	10·165304	39
22	751654	308	916687	144	834967	452	165033	38
23	751839	308	916600	144	835238	452	164762	37
24	752023	307	916514	144	835509	452	164491	36
25	752208	307	916427	144	835780	451	164220	35
26	752392	307	916341	144	836051	451	163949	34
27	752576	307	916254	144	836322	451	163678	33
28	752760	307	916167	145	836593	451	163407	32
29	752944	306	916081	145	836864	451	163136	31
30	753128	306	915994	145	837134	451	162866	30
31	9·753312	306	9·915907	145	9·837405	451	10·162595	29
32	753495	306	915820	145	837675	451	162325	28
33	753679	306	915733	145	837946	451	162054	27
34	753862	305	915646	145	838216	451	161784	26
35	754046	305	915559	145	838487	450	161513	25
36	754229	305	915472	145	838757	450	161243	24
37	754412	305	915385	145	839027	450	160973	23
38	754595	305	915297	145	839297	450	160703	22
39	754778	304	915210	145	839568	450	160432	21
40	754960	304	915123	146	839838	450	160162	20
41	9·755143	304	9·915035	146	9·840108	450	10·159892	19
42	755326	304	914948	146	840378	450	159622	18
43	755508	304	914860	146	840647	450	159353	17
44	755690	304	914773	146	840917	449	159083	16
45	755872	303	914685	146	841187	449	158813	15
46	756054	303	914598	146	841457	449	158543	14
47	756236	303	914510	146	841726	449	158274	13
48	756418	303	914422	146	841996	449	158004	12
49	756600	303	914334	146	842266	449	157734	11
50	756782	302	914246	147	842535	449	157465	10
51	9·756963	302	9·914158	147	9·842805	449	10·157195	9
52	757144	302	914070	147	843074	449	156926	8
53	757326	302	913982	147	843343	449	156657	7
54	757507	302	913894	147	843612	449	156388	6
55	757688	301	913806	147	843882	448	156118	5
56	757869	301	913718	147	844151	448	155849	4
57	758050	301	913630	147	844420	448	155580	3
58	758230	301	913541	147	844689	448	155311	2
59	758411	301	913453	147	844958	448	155042	1
60	758591	301	913365	147	845227	448	154773	0
	Cosine		Sine		Cotang.		Tang.	M.

55 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·758591	301	9·913365	147	9.845227	448	10·154773	60
1	758772	300	913276	147	845496	448	154504	59
2	758952	300	913187	148	845764	448	154236	58
3	759132	300	913099	148	846033	448	153967	57
4	759312	300	913010	148	846302	448	153698	56
5	759492	300	912922	148	846570	447	153430	55
6	759672	299	912833	148	846839	447	153161	54
7	759852	299	912744	148	847107	447	152893	53
8	760031	299	912655	148	847376	447	152624	52
9	760211	299	912566	148	847644	447	152356	51
10	760390	299	912477	148	847913	447	152087	50
11	9·760569	298	9·912388	148	9.848181	447	10·151819	49
12	760748	298	912299	149	848449	447	151551	48
13	760927	298	912210	149	848717	447	151283	47
14	761106	298	912121	149	848986	447	151014	46
15	761285	298	912031	149	849254	447	150746	45
16	761464	298	911942	149	849522	447	150478	44
17	761642	297	911853	149	849790	446	150210	43
18	761821	297	911763	149	850058	446	149942	42
19	761999	297	911674	149	850325	446	149675	41
20	762177	297	911584	149	850593	446	149407	40
21	9·762356	297	9·911495	149	9·850861	446	10·149139	39
22	762534	296	911405	149	851129	446	148871	38
23	762712	296	911315	150	851396	446	148604	37
24	762889	296	911226	150	851664	446	148336	36
25	763067	296	911136	150	851931	446	148069	35
26	763245	296	911046	150	852199	446	147801	34
27	763422	296	910956	150	852466	446	147534	33
28	763600	295	910866	150	852733	445	147267	32
29	763777	295	910776	150	853001	445	146999	31
30	763954	295	910686	150	853268	445	146732	30
31	9·764131	295	9·910596	150	9·853535	445	10·146465	29
32	764308	295	910506	150	853802	445	146198	28
33	764485	294	910415	150	854069	445	145931	27
34	764662	294	910325	151	854336	445	145664	26
35	764838	294	910235	151	854603	445	145397	25
36	765015	294	910144	151	854870	445	145130	24
37	765191	294	910054	151	855137	445	144863	23
38	765367	294	909963	151	855404	445	144596	22
39	765544	293	909873	151	855671	444	144329	21
40	765720	293	909782	151	855938	444	144062	20
41	9·765896	293	9·909691	151	9·856204	444	10·143796	19
42	766072	293	909601	151	856471	444	143529	18
43	766247	293	909510	151	856737	444	143263	17
44	766423	293	909419	151	857004	444	142996	6
45	766598	292	909328	152	857270	444	142730	5
46	766774	292	909237	152	857537	444	142463	4
47	766949	292	909146	152	857803	444	142197	13
48	767124	292	909055	152	858069	444	141931	12
49	767300	292	908964	152	858336	444	141664	11
50	767475	291	908873	152	858602	443	141398	10
51	9·767649	291	9·908781	152	9·858868	443	10·141132	9
52	767824	291	908690	152	859134	443	140866	8
53	767999	291	908599	152	859400	443	140600	7
54	768173	291	908507	152	859666	443	140334	6
55	768348	290	908416	153	859932	443	140068	5
56	768522	290	908324	153	860198	443	139802	4
57	768697	290	908233	153	860464	443	139536	3
58	768871	290	908141	153	860730	443	139270	2
59	769045	290	908049	153	860995	443	139005	1
60	769219	290	907958	153	861261	443	138739	0
	Cosine		Sine		Cotang.		Tang.	M.

54 Degrees

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·769219	290	9·907958	153	9·861261	443	10·138739	60
1	769393	289	907866	153	861527	443	138473	59
2	769566	289	907774	153	861792	442	138208	58
3	769740	289	907682	153	862058	442	137942	57
4	769913	289	907590	153	862323	442	137677	56
5	770087	289	907498	153	862589	442	137411	55
6	770260	288	907406	153	862854	442	137146	54
7	770433	288	907314	154	863119	442	136881	53
8	770606	288	907222	154	863385	442	136615	52
9	770779	288	907129	154	863650	442	136350	51
10	770952	288	907037	154	863915	442	136085	50
11	9·771125	288	9·906945	154	9·864180	442	10·135820	49
12	771298	287	906852	154	864445	442	135555	48
13	771470	287	906760	154	864710	442	135290	47
14	771643	287	906667	154	864975	441	135025	46
15	771815	287	906575	154	865240	441	134760	45
16	771987	287	906482	154	865505	441	134495	44
17	772159	287	906389	155	865770	441	134230	43
18	772331	286	906296	155	866035	441	133965	42
19	772503	286	906204	155	866300	441	133700	41
20	772675	286	906111	155	866564	441	133436	40
21	9·772847	286	9·906018	155	9·866829	441	10·133171	39
22	773018	286	905925	155	867094	441	132906	38
23	773190	286	905832	155	867358	441	132642	37
24	773361	285	905739	155	867623	441	132377	36
25	773533	285	905645	155	867887	441	132113	35
26	773704	285	905552	155	868152	440	131848	34
27	773875	285	905459	155	868416	440	131584	33
28	774046	285	905366	156	868680	440	131320	32
29	774217	285	905272	156	868945	440	131055	31
30	774388	284	905179	156	869209	440	130791	30
31	9·774558	284	9·905085	156	9·869473	440	10·130527	29
32	774729	284	904992	156	869737	440	130263	28
33	774899	284	904898	156	870001	440	129999	27
34	775070	284	904804	156	870265	440	129735	26
35	775240	284	904711	156	870529	440	129471	25
36	775410	283	904617	156	870793	440	129207	24
37	775580	283	904523	156	871057	440	128943	23
38	775750	283	904429	157	871321	440	128679	22
39	775920	283	904335	157	871585	440	128415	21
40	776090	283	904241	157	871849	439	128151	20
41	9·776259	283	9·904147	157	9·872112	439	10·127888	19
42	776429	282	904053	157	872376	439	127624	18
43	776598	282	903959	157	872640	439	127360	17
44	776768	282	903864	157	872903	439	127097	16
45	776937	282	903770	157	873167	439	126833	15
46	777106	282	903676	157	873430	439	126570	14
47	777275	281	903581	157	873694	439	126306	13
48	777444	281	903487	157	873957	439	126043	12
49	777613	281	903392	158	874220	439	125780	11
50	777781	281	903298	158	874484	439	125516	10
51	9·777950	281	9·903203	158	9·874747	439	10·125253	9
52	778119	281	903108	158	875010	439	124990	8
53	778287	280	903014	158	875273	438	124727	7
54	778455	280	902919	158	875536	438	124464	6
55	778624	280	902824	158	875800	438	124200	5
56	778792	280	902729	158	876063	438	123937	4
57	778960	280	902634	158	876326	438	123674	3
58	779128	280	902539	159	876589	438	123411	2
59	779295	279	902444	159	876851	438	123149	1
60	779463	279	902349	159	877114	438	122886	0
	Cosine		Sine		Cotang.		Tang.	M.

53 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·758591	301	9·913365	147	9.845227	448	10·154773	60
1	758772	300	913276	147	845496	448	154504	59
2	758952	300	913187	148	845764	448	154236	58
3	759132	300	913099	148	846033	448	153967	57
4	759312	300	913010	148	846302	448	153698	56
5	759492	300	912922	148	846570	447	153430	55
6	759672	299	912833	148	846839	447	153161	54
7	759852	299	912744	148	847107	447	152893	53
8	760031	299	912655	148	847376	447	152624	52
9	760211	299	912566	148	847644	447	152356	51
10	760390	299	912477	148	847913	447	152087	50
11	9·760569	298	9·912388	148	9.848181	447	10·151819	49
12	760748	298	912299	149	848449	447	151551	48
13	760927	298	912210	149	848717	447	151283	47
14	761106	298	912121	149	848986	447	151014	46
15	761285	298	912031	149	849254	447	150746	45
16	761464	298	911942	149	849522	447	150478	44
17	761642	297	911853	149	849790	446	150210	43
18	761821	297	911763	149	850058	446	149942	42
19	761999	297	911674	149	850325	446	149675	41
20	762177	297	911584	149	850593	446	149407	40
21	9·762356	297	9·911495	149	9·850861	446	10·149139	39
22	762534	296	911405	149	851129	446	148871	38
23	762712	296	911315	150	851396	446	148604	37
24	762889	296	911226	150	851664	446	148336	36
25	763067	296	911136	150	851931	446	148069	35
26	763245	296	911046	150	852199	446	147801	34
27	763422	296	910956	150	852466	446	147534	33
28	763600	295	910866	150	852733	445	147267	32
29	763777	295	910776	150	853001	445	146999	31
30	763954	295	910686	150	853268	445	146732	30
31	9·764131	295	9·910596	150	9·853535	445	10·146465	29
32	764308	295	910506	150	853802	445	146198	28
33	764485	294	910415	150	854069	445	145931	27
34	764662	294	910325	151	854336	445	145664	26
35	764838	294	910235	151	854603	445	145397	25
36	765015	294	910144	151	854870	445	145130	24
37	765191	294	910054	151	855137	445	144863	23
38	765367	294	909963	151	855404	445	144596	22
39	765544	293	909873	151	855671	444	144329	21
40	765720	293	909782	151	855938	444	144062	20
41	9·765896	293	9·909691	151	9·856204	444	10·143796	19
42	766072	293	909601	151	856471	444	143529	18
43	766247	293	909510	151	856737	444	143263	17
44	766423	293	909419	151	857004	444	142996	16
45	766598	292	909328	152	857270	444	142730	15
46	766774	292	909237	152	857537	444	142463	14
47	766949	292	909146	152	857803	444	142197	13
48	767124	292	909055	152	858069	444	141931	12
49	767300	292	908964	152	858336	444	141664	11
50	767475	291	908873	152	858602	443	141398	10
51	9·767649	291	9·908781	152	9·858868	443	10·141132	9
52	767824	291	908690	152	859134	443	140866	8
53	767999	291	908599	152	859400	443	140600	7
54	768173	291	908507	152	859666	443	140334	6
55	768348	290	908416	153	859932	443	140068	5
56	768522	290	908324	153	860198	443	139802	4
57	768697	290	908233	153	860464	443	139536	3
58	768871	290	908141	153	860730	443	139270	2
59	769045	290	908049	153	860995	443	139005	1
60	769219	290	907958	153	861261	443	138739	0
	Cosine		Sine		Cotang.		Tang.	M.

54 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·789342	269	9·896532	164	9·892810	434	10·107190	60
1	789504	269	896433	165	893070	434	106930	59
2	789665	269	896335	165	893331	434	106669	58
3	789827	269	896236	165	893591	434	106409	57
4	789988	269	896137	165	893851	434	106149	56
5	790149	269	896038	165	894111	434	105889	55
6	790310	268	895939	165	894371	434	105629	54
7	790471	268	895840	165	894632	433	105368	53
8	790632	268	895741	165	894892	433	105108	52
9	790793	268	895641	165	895152	433	104848	51
10	790954	268	895542	165	895412	433	104588	50
11	9·791115	268	9·895443	166	9·895672	433	10·104328	49
12	791275	267	895343	165	895932	433	104068	48
13	791436	267	895244	166	896192	433	103808	47
14	791596	267	895145	166	896452	433	103548	46
15	791757	267	895045	166	896712	433	103288	45
16	791917	267	894945	166	896971	433	103029	44
17	792077	267	894846	166	897231	433	102769	43
18	792237	266	894746	166	897491	433	102509	42
19	792397	266	894646	166	897751	433	102249	41
20	792557	266	894546	166	898010	433	101990	40
21	9·792716	266	9·894446	167	9·898270	433	10·101730	39
22	792876	266	894346	167	898530	433	101470	38
23	793035	266	894246	167	898789	433	101211	37
24	793195	265	894146	167	899049	432	100951	36
25	793354	265	894046	167	899308	432	100692	35
26	793514	265	893946	167	899568	432	100432	34
27	793673	265	893846	167	899827	432	100173	33
28	793832	265	893745	167	900086	432	099914	32
29	793991	265	893645	167	900346	432	099654	31
30	794150	264	893544	167	900605	432	099395	30
31	9·794308	264	9·893444	168	9·900864	432	10·099136	29
32	794467	264	893343	168	901124	432	098876	28
33	794626	264	893243	168	901383	432	098617	27
34	794784	264	893142	168	901642	432	098358	26
35	794942	264	893041	168	901901	432	098099	25
36	795101	264	892940	168	902160	432	097840	24
37	795259	264	892839	168	902419	432	097581	23
38	795417	263	892739	168	902679	432	097321	22
39	795575	263	892638	168	902938	432	097062	21
40	795733	263	892536	168	903197	431	096803	20
41	9·795891	263	9·892435	169	9·903455	431	10·096545	19
42	796049	263	892334	169	903714	431	096286	18
43	796206	263	892233	169	903973	431	096027	17
44	796364	262	892132	169	904232	431	095768	16
45	796521	262	892030	169	904491	431	095509	15
46	796679	262	891929	169	904750	431	095250	14
47	796836	262	891827	169	905008	431	094992	13
48	796993	262	891726	169	905267	431	094733	12
49	797150	261	891624	169	905526	431	094474	11
50	797307	261	891523	170	905784	431	094216	10
51	9·797464	261	9·891421	170	9·906043	431	10·093957	9
52	797621	261	891319	170	906302	431	093698	8
53	797777	261	891217	170	906560	431	093440	7
54	797934	261	891115	170	906819	431	093181	6
55	798091	261	891013	170	907077	431	092923	5
56	798247	261	890911	170	907336	431	092664	4
57	798403	260	890809	170	907594	431	092406	3
58	798560	260	890707	170	907852	431	092148	2
59	798716	260	890605	170	908111	430	091889	1
60	798872	260	890503	170	908369	430	091631	0
	Cosine		Sine		Cotang.		Tang.	M.

51 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·798872	260	9·890503	170	9·908369	430	10·091631	60
1	799028	260	890400	171	908628	430	091372	59
2	799184	260	890298	171	908886	430	091114	58
3	799339	259	890195	171	909144	430	090856	57
4	799495	259	890093	171	909402	430	090598	56
5	799651	259	889990	171	909660	430	090340	55
6	799806	259	889888	171	909918	430	090082	54
7	799962	259	889785	171	910177	430	089823	53
8	800117	259	889682	171	910435	430	089565	52
9	800272	258	889579	171	910693	430	089307	51
10	800427	258	889477	171	910951	430	089049	50
11	9·800582	258	9·889374	172	9·911209	430	10·088791	49
12	800737	258	889271	172	911467	430	088533	48
13	800892	258	889168	172	911724	430	088276	47
14	801047	258	889064	172	911982	430	088018	46
15	801201	258	888961	172	912240	430	087760	45
16	801356	257	888858	172	912498	430	087502	44
17	801511	257	888755	172	912756	430	087244	43
18	801665	257	888651	172	913014	429	086986	42
19	801819	257	888548	172	913271	429	086729	41
20	801973	257	888444	173	913529	429	086471	40
21	9·802128	257	9·888341	173	9·913787	429	10·086213	39
22	802282	256	888237	173	914044	429	085956	38
23	802436	256	888134	173	914302	429	085698	37
24	802589	256	888030	173	914560	429	085440	36
25	802743	256	887926	173	914817	429	085183	35
26	802897	256	887822	173	915075	429	084925	34
27	803050	256	887718	173	915332	429	084668	33
28	803204	256	887614	173	915590	429	084410	32
29	803357	255	887510	173	915847	429	084153	31
30	803511	255	887406	174	916104	429	083896	30
31	9·803664	255	9·887302	174	9·916362	429	10·083638	29
32	803817	255	887198	174	916619	429	083381	28
33	803970	255	887093	174	916877	429	083123	27
34	804123	255	886989	174	917134	429	082866	26
35	804276	254	886885	174	917391	429	082609	25
36	804428	254	886780	174	917648	429	082352	24
37	804581	254	886676	174	917905	429	082095	23
38	804734	254	886571	174	918163	428	081837	22
39	804886	254	886466	174	918420	428	081580	21
40	805039	254	886362	175	918677	428	081323	20
41	9·805191	254	9·886257	175	9·918934	428	10·081066	19
42	805343	253	886152	175	919191	428	080809	18
43	805495	253	886047	175	919448	428	080552	17
44	805647	253	885942	175	919705	428	080295	16
45	805799	253	885837	175	919962	428	080038	15
46	805951	253	885732	175	920219	428	079781	14
47	806103	253	885627	175	920476	428	079524	13
48	806254	253	885522	175	920733	428	079267	12
49	806406	252	885416	175	920990	428	079010	11
50	806557	252	885311	176	921247	428	078753	10
51	9·806709	252	9·885205	176	9·921503	428	10·078497	9
52	806860	252	885100	176	921760	428	078240	8
53	807011	252	884994	176	922017	428	077983	7
54	807163	252	884889	176	922274	428	077726	6
55	807314	252	884783	176	922530	428	077470	5
56	807465	251	884677	176	922787	428	077213	4
57	807615	251	884572	176	923044	428	076956	3
58	807766	251	884466	176	923300	428	076700	2
59	807917	251	884360	176	923557	427	076443	1
60	808067	251	884254	177	923813	427	076187	0
	Cosine		Sine		Cotang.		Tang.	M.

50 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·808067	251	9·884254	177	9·923813	427	10·076187	60
1	808218	251	884148	177	924070	427	075930	59
2	808368	251	884042	177	924327	427	075673	58
3	808519	250	883936	177	924583	427	075417	57
4	808669	250	883829	177	924840	427	075160	56
5	808819	250	883723	177	925096	427	074904	55
6	808969	250	883617	177	925352	427	074648	54
7	809119	250	883510	177	925609	427	074391	53
8	809269	250	883404	177	925865	427	074135	52
9	809419	249	883297	178	926122	427	073878	51
10	809569	249	883191	178	926378	427	073622	50
11	9·809718	249	9·883084	178	9·926634	427	10·073366	49
12	809868	249	882977	178	926890	427	073110	48
13	810017	249	882871	178	927147	427	072853	47
14	810167	249	882764	178	927403	427	072597	46
15	810316	248	882657	178	927659	427	072341	45
16	810465	248	882550	178	927915	427	072085	44
17	810614	248	882443	178	928171	427	071829	43
18	810763	248	882336	179	928427	427	071573	42
19	810912	248	882229	179	928683	427	071317	41
20	811061	248	882121	179	928940	427	071060	40
21	9·811210	248	9·882014	179	9·929196	427	10·070804	39
22	811358	247	881907	179	929452	427	070548	38
23	811507	247	881799	179	929708	427	070292	37
24	811655	247	881692	179	929964	426	070036	36
25	811804	247	881584	179	930220	426	069780	35
26	811952	247	881477	179	930475	426	069525	34
27	812100	247	881369	179	930731	426	069269	33
28	812248	247	881261	180	930987	426	069013	32
29	812396	246	881153	180	931243	426	068757	31
30	812544	246	881046	180	931499	426	068501	30
31	9·812692	246	9·880938	180	9·931755	426	10·068245	29
32	812840	246	880830	180	932010	426	067990	28
33	812988	246	880722	180	932266	426	067734	27
34	813135	246	880613	180	932522	426	067478	26
35	813283	246	880505	180	932778	426	067222	25
36	813430	245	880397	180	933033	426	066967	24
37	813578	245	880289	181	933289	426	066711	23
38	813725	245	880180	181	933545	426	066455	22
39	813872	245	880072	181	933800	426	066200	21
40	814019	245	879963	181	934056	426	065944	20
41	9·814166	245	9·879855	181	9·934311	426	10·065689	19
42	814313	245	879746	181	934567	426	065433	18
43	814460	244	879637	181	934823	426	065177	17
44	814607	244	879529	181	935078	426	064922	16
45	814753	244	879420	181	935333	426	064667	15
46	814900	244	879311	181	935589	426	064411	14
47	815046	244	879202	182	935844	426	064156	13
48	815193	244	879093	182	936100	426	063900	12
49	815339	244	878984	182	936355	426	063645	11
50	815485	243	878875	182	936610	426	063390	10
51	9·815631	243	9·878766	182	9·936866	425	10·063134	9
52	815778	243	878656	182	937121	425	062879	8
53	815924	243	878547	182	937376	425	062624	7
54	816069	243	878438	182	937632	425	062368	6
55	816215	243	878328	182	937887	425	062113	5
56	816361	243	878219	183	938142	425	061858	4
57	816507	242	878109	183	938398	425	061602	3
58	816652	242	877999	183	938653	425	061347	2
59	816798	242	877890	183	938908	425	061092	1
60	816943	242	877780	183	939163	425	060837	0
	Cosine		Sine		Cotang.		Tang.	M.

49 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·816943	242	9 877780	183	9·939163	425	10·060837	60
1	817088	242	877670	183	939418	425	060582	59
2	817233	242	877560	183	939673	425	060327	58
3	817379	242	877450	183	939928	425	060072	57
4	817524	241	877340	183	940183	425	059817	56
5	817668	241	877230	184	940438	425	059562	55
6	817813	241	877120	184	940694	425	059306	54
7	817958	241	877010	184	940949	425	059051	53
8	818103	241	876899	184	941204	425	058796	52
9	818247	241	876789	184	941458	425	058542	51
10	818392	241	876678	184	941714	425	058286	50
11	9·818536	240	9 876568	184	9·941968	425	10·058032	49
12	818681	240	876457	184	942223	425	057777	48
13	818825	240	876347	184	942478	425	057522	47
14	818969	240	876236	185	942733	425	057267	46
15	819113	240	876125	185	942988	425	057012	45
16	819257	240	876014	185	943243	425	056757	44
17	819401	240	875904	185	943498	425	056502	43
18	819545	239	875793	185	943752	425	056248	42
19	819689	239	875682	185	944007	425	055993	41
20	819832	239	875571	185	944262	425	055738	40
21	9·819976	239	9·875459	185	9·944517	425	10·055483	39
22	820120	239	875348	185	944771	424	055229	38
23	820263	239	875237	185	945026	424	054974	37
24	820406	239	875126	186	945281	424	054719	36
25	820550	238	875014	186	945535	424	054465	35
26	820693	238	874903	186	945790	424	054210	34
27	820836	238	874791	186	946045	424	053955	33
28	820979	238	874680	186	946299	424	053701	32
29	821122	238	874568	186	946554	424	053446	31
30	821265	238	874456	186	946808	424	053192	30
31	9·821407	238	9·874344	186	9·947063	424	10·052937	29
32	821550	238	874232	187	947318	424	052682	28
33	821693	237	874121	187	947572	424	052428	27
34	821835	237	874009	187	947826	424	052174	26
35	821977	237	873896	187	948081	424	051919	25
36	822120	237	873784	187	948336	424	051664	24
37	822262	237	873672	187	948590	424	051410	23
38	822404	237	873560	187	948844	424	051156	22
39	822546	237	873448	187	949099	424	050901	21
40	822688	236	873335	187	949353	424	050647	20
41	9·822830	236	9·873223	187	9·949607	424	10.050393	19
42	822972	236	873110	188	949862	424	050138	18
43	823114	236	872998	188	950116	424	049884	17
44	823255	236	872885	188	950370	424	049630	16
45	823397	236	872772	188	950625	424	049375	15
46	823539	236	872659	188	950879	424	049121	14
47	823680	235	872547	188	951133	424	048867	13
48	823821	235	872434	188	951388	424	048612	12
49	823963	235	872321	188	951642	424	048358	11
50	824104	235	872208	188	951896	424	048104	10
51	9·824245	235	9·872095	189	9·952150	424	10·047850	9
52	824386	235	871981	189	952405	424	047595	8
53	824527	235	871868	189	952659	424	047341	7
54	824668	234	871755	189	952913	424	047087	6
55	824808	234	871641	189	953167	423	046833	5
56	824949	234	871528	189	953421	423	046579	4
57	825090	234	871414	189	953675	423	046325	3
58	825230	234	871301	189	953929	423	046071	2
59	825371	234	871187	189	954183	423	045817	1
60	825511	234	871073	190	954437	423	045563	0
	Cosine		Sine		Cotang.		Tang.	M.

48 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·825511	234	9·871073	190	9·954437	423	10·045563	60
1	825651	233	870960	190	954691	423	045309	59
2	825791	233	870846	190	954945	423	045055	58
3	825931	233	870732	190	955200	423	044800	57
4	826071	233	870618	190	955454	423	044546	56
5	826211	233	870504	190	955707	423	044293	55
6	826351	233	870390	190	955961	423	044039	54
7	826491	233	870276	190	956215	423	043785	53
8	826631	233	870161	190	956469	423	043531	52
9	826770	232	870047	191	956723	423	043277	51
10	826910	232	869933	191	956977	423	043023	50
11	9·827049	232	9·869818	191	9·957231	423	10·042769	49
12	827189	232	869704	191	957485	423	042515	48
13	827328	232	869589	191	957739	423	042261	47
14	827467	232	869474	191	957993	423	042007	46
15	827606	232	869360	191	958246	423	041754	45
16	827745	232	869245	191	958500	423	041500	44
17	827884	231	869130	191	958754	423	041246	43
18	828023	231	869015	192	959008	423	040992	42
19	828162	231	868900	192	959262	423	040738	41
20	828301	231	868785	192	959516	423	040484	40
21	9·828439	231	9·868670	192	9·959769	423	10·040231	39
22	828578	231	868555	192	960023	423	039977	38
23	828716	231	868440	192	960277	423	039723	37
24	828855	230	868324	192	960531	423	039469	36
25	828993	230	868209	192	960784	423	039216	35
26	829131	230	868093	192	961038	423	038962	34
27	829269	230	867978	193	961291	423	038709	33
28	829407	230	867862	193	961545	423	038455	32
29	829545	230	867747	193	961799	423	038201	31
30	829683	230	867631	193	962052	423	037948	30
31	9·829821	229	9·867515	193	9·962306	423	10·037694	29
32	829959	229	867399	193	962560	423	037440	28
33	830097	229	867283	193	962813	423	037187	27
34	830234	229	867167	193	963067	423	036933	26
35	830372	229	867051	193	963320	423	036680	25
36	830509	229	866935	194	963574	423	036426	24
37	830646	229	866819	194	963827	423	036173	23
38	830784	229	866703	194	964081	423	035919	22
39	830921	228	866586	194	964335	423	035665	21
40	831058	228	866470	194	964588	422	035412	20
41	9·831195	228	9·866353	194	9·964842	422	10·035158	19
42	831332	228	866237	194	965095	422	034905	18
43	831469	228	866120	194	965349	422	034651	17
44	831606	228	866004	195	965602	422	034398	16
45	831742	228	865887	195	965855	422	034145	15
46	831879	228	865770	195	966109	422	033891	14
47	832015	227	865653	195	966362	422	033638	13
48	832152	227	865536	195	966616	422	033384	12
49	832288	227	865419	195	966869	422	033131	11
50	832425	227	865302	195	967123	422	032877	10
51	9·832561	227	9·865185	195	9·967376	422	10·032624	9
52	832697	227	865068	195	967629	422	032371	8
53	832833	227	864950	195	967883	422	032117	7
54	832969	226	864833	196	968136	422	031864	6
55	833105	226	864716	196	968389	422	031611	5
56	833241	226	864598	196	968643	422	031357	4
57	833377	226	864481	196	968896	422	031104	3
58	833512	226	864363	196	969149	422	030851	2
59	833648	226	864245	196	969403	422	030597	1
60	833783	226	864127	196	969656	422	030344	0
	Cosine		Sine		Cotang.		Tang.	M.

47 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·816943	242	9·877780	183	9·939163	425	10·060837	60
1	817088	242	877670	183	939418	425	060582	59
2	817233	242	877560	183	939673	425	060327	58
3	817379	242	877450	183	939928	425	060072	57
4	817524	241	877340	183	940183	425	059817	56
5	817668	241	877230	184	940438	425	059562	55
6	817813	241	877120	184	940694	425	059306	54
7	817958	241	877010	184	940949	425	059051	53
8	818103	241	876899	184	941204	425	058796	52
9	818247	241	876789	184	941458	425	058542	51
10	818392	241	876678	184	941714	425	058286	50
11	9·818536	240	9·876568	184	9·941968	425	10·058032	49
12	818681	240	876457	184	942223	425	057777	48
13	818825	240	876347	184	942478	425	057522	47
14	818969	240	876236	185	942733	425	057267	46
15	819113	240	876125	185	942988	425	057012	45
16	819257	240	876014	185	943243	425	056757	44
17	819401	240	875904	185	943498	425	056502	43
18	819545	239	875793	185	943752	425	056248	42
19	819689	239	875682	185	944007	425	055993	41
20	819832	239	875571	185	944262	425	055738	40
21	9·819976	239	9·875459	185	9·944517	425	10·055483	39
22	820120	239	875348	185	944771	424	055229	38
23	820263	239	875237	185	945026	424	054974	37
24	820406	239	875126	186	945281	424	054719	36
25	820550	238	875014	186	945535	424	054465	35
26	820693	238	874903	186	945790	424	054210	34
27	820836	238	874791	186	946045	424	053955	33
28	820979	238	874680	186	946299	424	053701	32
29	821122	238	874568	186	946554	424	053446	31
30	821265	238	874456	186	946808	424	053192	30
31	9·821407	238	9·874344	186	9·947063	424	10·052937	29
32	821550	238	874232	187	947318	424	052682	28
33	821693	237	874121	187	947572	424	052428	27
34	821835	237	874009	187	947826	424	052174	26
35	821977	237	873896	187	948081	424	051919	25
36	822120	237	873784	187	948336	424	051664	24
37	822262	237	873672	187	948590	424	051410	23
38	822404	237	873560	187	948844	424	051156	22
39	822546	237	873448	187	949099	424	050901	21
40	822688	236	873335	187	949353	424	050647	20
41	9·822830	236	9·873223	187	9·949607	424	10.050393	19
42	822972	236	873110	188	949862	424	050138	18
43	823114	236	872998	188	950116	424	049884	17
44	823255	236	872885	188	950370	424	049630	16
45	823397	236	872772	188	950625	424	049375	15
46	823539	236	872659	188	950879	424	049121	14
47	823680	235	872547	188	951133	424	048867	13
48	823821	235	872434	188	951388	424	048612	12
49	823963	235	872321	188	951642	424	048358	11
50	824104	235	872208	188	951896	424	048104	10
51	9·824245	235	9·872095	189	9·952150	424	10·047850	9
52	824386	235	871981	189	952405	424	047595	8
53	824527	235	871868	189	952659	424	047341	7
54	824668	234	871755	189	952913	424	047087	6
55	824808	234	871641	189	953167	423	046833	5
56	824949	234	871528	189	953421	423	046579	4
57	825090	234	871414	189	953675	423	046325	3
58	825230	234	871301	189	953929	423	046071	2
59	825371	234	871187	189	954183	423	045817	1
60	825511	234	871073	190	954437	423	045563	0
	Cosine		Sine		Cotang.		Tang.	M.

48 Degrees.

M.	Sine	D	Cosine	D.	Tang.	D.	Cotang.	
0	9·841771	218	9·856934	203	9·984837	421	10·015163	60
1	841902	218	856812	203	985090	421	014910	59
2	842033	218	856690	204	985343	421	014657	58
3	842163	217	856568	204	985596	421	014404	57
4	842294	217	856446	204	985848	421	014152	56
5	842424	217	856323	204	986101	421	013899	55
6	842555	217	856201	204	986354	421	013646	54
7	842685	217	856078	204	986607	421	013393	53
8	842815	217	855956	204	986860	421	013140	52
9	842946	217	855833	204	987112	421	012888	51
10	843076	217	855711	205	987365	421	012635	50
11	9·843206	216	9·855588	205	9·987618	421	10·012382	49
12	843336	216	855465	205	987871	421	012129	48
13	843466	216	855342	205	988123	421	011877	47
14	843595	216	855219	205	988376	421	011624	46
15	843725	216	855096	205	988629	421	011371	45
16	843855	216	854973	205	988882	421	011118	44
17	843984	216	854850	205	989134	421	010866	43
18	844114	215	854727	206	989387	421	010613	42
19	844243	215	854603	206	989640	421	010360	41
20	844372	215	854480	206	989893	421	010107	40
21	9·844502	215	9·854356	206	9·990145	421	10·009855	39
22	844631	215	854233	206	990398	421	009602	38
23	844760	215	854109	206	990651	421	009349	37
24	844889	215	853986	206	990903	421	009097	36
25	845018	215	853862	206	991156	421	008844	35
26	845147	215	853738	206	991409	421	008591	34
27	845276	214	853614	207	991662	421	008338	33
28	845405	214	853490	207	991914	421	008086	32
29	845533	214	853366	207	992167	421	007833	31
30	845662	214	853242	207	992420	421	007580	30
31	9·845790	214	9·853118	207	9·992672	421	10·007328	29
32	845919	214	852994	207	992925	421	007075	28
33	846047	214	852869	207	993178	421	006822	27
34	846175	214	852745	207	993430	421	006570	26
35	846304	214	852620	207	993683	421	006317	25
36	846432	213	852496	208	993936	421	006064	24
37	846560	213	852371	208	994189	421	005811	23
38	846688	213	852247	208	994441	421	005559	22
39	846816	213	852122	208	994694	421	005306	21
40	846944	213	851997	208	994947	421	005053	20
41	9·847071	213	9·851872	208	9·995199	421	10·004801	19
42	847199	213	851747	208	995452	421	004548	18
43	847327	213	851622	208	995705	421	004295	17
44	847454	212	851497	209	995957	421	004043	16
45	847582	212	851372	209	996210	421	003790	15
46	847709	212	851246	209	996463	421	003537	14
47	847836	212	851121	209	996715	421	003285	13
48	847964	212	850996	209	996968	421	003032	12
49	848091	212	850870	209	997221	421	002779	11
50	848218	212	850745	209	997473	421	002527	10
51	9·848345	212	9·850619	209	9·997726	421	10·002274	9
52	848472	211	850493	210	997979	421	002021	8
53	848599	211	850368	210	998231	421	001769	7
54	848726	211	850242	210	998484	421	001516	6
55	848852	211	850116	210	998737	421	001263	5
56	848979	211	849990	210	998989	421	001011	4
57	849106	211	849864	210	999242	421	000758	3
58	849232	211	849738	210	999495	421	000505	2
59	849359	211	849611	210	999748	421	000253	1
60	849485	211	849485	210	10·000000	421	000000	0
	Cosine		Sine		Cotang.		Tang.	M.

45 Degrees

TABLE XIV.

NATURAL SINES AND TANGENTS.

′	16°	17°	18°	19°	20°	21°	22°	23°	′
0	.275 6374	·292 3717	·309 0170	·325 5682	·342 0201	·358 3679	·374 6066	·390 7311	60
1	9170	6499	2936	8432	2935	6395	8763	9989	59
2	·276 1966	9280	5702	·326 1182	5668	9110	·375 1459	.391 2666	58
3	4761	·293 2061	8468	3932	8400	·359 1825	4156	5343	57
4	7556	4842	·310 1234	6681	·343 1133	4540	6852	8019	56
5	·277 0352	7623	3999	9430	3865	7254	9547	·392 0695	55
6	3147	·294 0403	6764	·327 2179	6597	9968	·376 2243	3371	54
7	5941	3183	9529	4928	9329	·360 2682	4938	6047	53
8	8736	5963	·311 2294	7676	·344 2060	5395	7632	8722	52
9	·278 1530	8743	5058	·328 0424	4791	8108	·377 0327	·393 1397	51
10	4324	·295 1522	7822	3172	7521	·361 0821	3021	4071	50
11	7118	4302	·312 0586	5919	·345 0252	3534	5714	6745	49
12	9911	7081	3349	8666	2982	6246	8408	9419	48
13	·279 2704	9859	6112	·329 1413	5712	8958	·378 1101	·394 2093	47
14	5497	·296 2638	8875	4160	8441	·362 1669	3794	4766	46
15	8290	5416	·313 1638	6906	·346 1171	4380	6486	7439	45
16	·280 1083	8194	4400	9653	3900	7091	9178	·395 0111	44
17	3875	·297 0971	7163	·330 2398	6628	9802	·379 1870	2783	43
18	6667	3749	9925	5144	9357	·363 2512	4562	5455	42
19	9459	6526	·314 2686	7889	·347 2085	5222	7253	8127	41
20	·281 2251	9303	5448	·331 0634	4812	7932	9944	·396 0798	40
21	5042	·298 2079	8209	3379	7540	·364 0641	380 2634	3468	39
22	7833	4856	·315 0969	6123	·348 0267	3351	5324	6139	38
23	·282 0624	7632	3730	8867	2994	6059	8014	8809	37
24	3415	·299 0408	6490	·332 1611	5720	8768	·381 0704	·397 1479	36
25	6205	3184	9250	4355	8447	·365 1476	3393	4148	35
26	8995	5959	·316 2010	7098	·349 1173	4184	6082	6818	34
27	·283 1785	8734	4770	9841	3898	6891	8770	9486	33
28	4575	·300 1509	7529	·333 2584	6624	9599	·382 1459	·398 2155	32
29	7364	4284	·317 0288	5326	9349	·366 2306	4147	4823	31
30	·284 0153	7058	3047	8069	·350 2074	5012	6834	7491	30
31	2942	9832	5805	·334 0810	4798	7719	9522	.399 0158	29
32	5731	·301 2606	8563	3552	7523	·367 0425	·383 2209	2825	28
33	8520	5380	·318 1321	6293	·351 0246	3130	4895	5492	27
34	·285 1308	8153	4079	9034	2970	5836	7582	8158	26
35	4096	·302 0926	6836	·335 1775	5693	8541	·384 0268	·400 0825	25
36	6884	3699	9593	4516	8416	·368 1246	2953	3490	24
37	9671	6471	·319 2350	7256	·352 1139	3950	5639	6156	23
38	·286 2458	9244	5106	9996	3862	6654	8324	8821	22
39	5246	·303 2016	7863	·336 2735	6584	9358	·385 1008	·401 1486	21
40	8032	4788	·320 0619	5475	9306	·369 2061	3693	4150	20
41	·287 0819	7559	3374	8214	·353 2027	4765	6377	6814	19
42	3605	·304 0331	6130	·337 0953	4748	7468	9060	9478	18
43	6391	3102	8885	3691	7469	·370 0170	·386 1744	·402 2141	17
44	9177	5872	·321 1640	6429	·354 0190	2872	4427	4804	16
45	·288 1963	8643	4395	9167	2910	5574	7110	7467	15
46	4748	·305 1413	7149	·338 1905	5630	8276	9792	·403 0129	14
47	7533	4183	9903	4642	8350	·371 0977	·387 2474	2791	13
48	·289 0318	6953	·322 2657	7379	·355 1070	3678	5156	5453	12
49	3103	9723	5411	·339 0116	3789	6379	7837	8114	11
50	5887	·306 2492	8164	2852	6508	9079	·388 0518	·404 0775	10
51	8671	5261	·323 0917	5589	9226	·372 1780	3199	3436	9
52	·290 1455	8030	3670	8325	·356 1944	4479	5880	6096	8
53	4239	·307 0798	6422	·340 1060	4662	7179	8560	8756	7
54	7022	3566	9174	3796	7380	9878	·389 1240	·405 1416	6
55	9805	6334	·324 1926	6531	·357 0097	·373 2577	3919	4075	5
56	·291 2588	9102	4678	9265	2814	5275	6598	6734	4
57	5371	·308 1869	7429	·341 2000	5531	7973	9277	9393	3
58	8153	4636	·325 0180	4734	8248	·374 0671	·390 1955	·406 2051	2
59	·292 0935	7403	2931	7468	·358 0964	3369	4633	4709	1
60	3717	·309 0170	5682	·342 0201	3679	6066	7311	7366	0
′	73°	72°	71°	70°	69°	68°	67°	66°	′

NAT. COSINE.

′	24°	25°	26°	27°	28°	29°	30°	31°	′
0	·406 7366	·422 6183	·438 3711	·453 9905	·469 4716	·484 8096	·500 0000	·515 0381	60
1	·407 0024	8819	6326	·454 2497	7284	·485 0640	2519	2874	59
2	2681	·423 1455	8940	5088	9852	3184	5037	5367	58
3	5337	4090	·439 1553	7679	·470 2419	5727	7556	7859	57
4	7993	6725	4166	·455 0269	4986	8270	·501 0073	·516 0351	56
5	·408 0649	9360	6779	2859	7553	·486 0812	2591	2842	55
6	3305	·424 1994	9392	5449	·471 0119	3354	5107	5333	54
7	5960	4628	·440 2004	8038	2685	5895	7624	7824	53
8	8615	7262	4615	·456 0627	5250	8436	·502 0140	·517 0314	52
9	·409 1269	9895	7227	3216	7815	·487 0977	2655	2804	51
10	3923	·425 2528	9838	5804	·472 0380	3517	5170	5293	50
11	6577	5161	·441 2448	8392	2944	6057	7685	7782	49
12	9230	7793	5059	·457 0979	5508	8597	·503 0199	·518 0271	48
13	·410 1883	·426 0425	7668	3566	8071	·488 1136	2713	2758	47
14	4536	3056	·442 0278	6153	·473 0634	3674	5227	5246	46
15	7189	5687	2887	8739	3197	6212	7740	7733	45
16	9841	8318	5496	·458 1325	5759	8750	·504 0252	·519 0219	44
17	·411 2492	·427 0949	8104	3910	8321	·489 1288	2765	2705	43
18	5144	3579	·443 0712	6496	·474 0882	3825	5276	5191	42
19	7795	6208	3319	9080	3443	6361	7788	7676	41
20	·412 0445	8838	5927	·459 1665	6004	8897	·505 0298	·520 0161	40
21	3096	·428 1467	8534	4248	8564	·490 1433	2809	2646	39
22	5745	4095	·444 1140	6832	·475 1124	3968	5319	5130	38
23	8395	6723	3746	9415	3683	6503	7828	7613	37
24	·413 1044	9351	6352	·460 1998	6242	9038	·506 0338	·521 0096	36
25	3693	·429 1979	8957	4580	8801	·491 1572	2846	2579	35
26	6342	4606	·445 1562	7162	·476 1359	4105	5355	5061	34
27	8990	7233	4167	9744	3917	6638	7863	7543	33
28	·414 1638	9859	6771	·461 2325	6474	9171	·507 0370	·522 0024	32
29	4285	·430 2485	9375	4906	9031	·492 1704	2877	2505	31
30	6932	5111	·446 1978	7486	·477 1588	4236	5384	4986	30
31	9579	7736	4581	·462 0066	4144	6767	7890	7466	29
32	·415 2226	·431 0361	7184	2646	6700	9298	·508 0396	9945	28
33	4872	2986	9786	5225	9255	·493 1829	2901	·523 2424	27
34	7517	5610	·447 2388	7804	·478 1810	4359	5406	4903	26
35	·416 0163	8234	4990	·463 0382	4364	6889	7910	7381	25
36	2808	·432 0857	7591	2960	6919	9419	·509 0414	9859	24
37	5453	3481	·448 0192	5538	9472	·494 1948	2918	·524 2336	23
38	8097	6103	2792	8115	·479 2026	4476	5421	4813	22
39	·417 0741	8726	5392	·464 0692	4579	7005	7924	7290	21
40	3385	·433 1348	7992	3269	7131	9532	·510 0426	9766	20
41	6028	3970	·449 0591	5845	9683	·495 2060	2928	·525 2241	19
42	8671	6591	3190	8420	·480 2235	4587	5429	4717	18
43	·418 1313	9212	5789	·465 0996	4786	7113	7930	7191	17
44	3956	·434 1832	8387	3571	7337	9639	·511 0431	9665	16
45	6597	4453	·450 0984	6145	9888	·496 2165	2931	·526 2139	15
46	9239	7072	3582	8719	·481 2438	4690	5431	4613	14
47	·419 1880	9692	6179	·466 1293	4987	7215	7930	7085	13
48	4521	·435 2311	8775	3866	7537	9740	·512 0429	9558	12
49	7161	4930	·451 1372	6439	·482 0086	·497 2264	2927	·527 2030	11
50	9801	7548	3967	9012	2634	4787	5425	4502	10
51	·420 2441	·436 0166	6563	·467 1584	5182	7310	7923	6973	9
52	5080	2784	9158	4156	7730	9833	·513 0420	9443	8
53	7719	5401	·452 1753	6727	·483 0277	·498 2355	2916	·528 1914	7
54	·421 0358	8018	4347	9298	2824	4877	5413	4383	6
55	2996	·437 0634	6941	·468 1869	5370	7399	7908	6853	5
56	5634	3251	9535	4439	7916	9920	·514 0404	9322	4
57	8272	5866	·453 2128	7009	·484 0462	·499 2441	2899	·529 1790	3
58	·422 0909	8482	4721	9578	3007	4961	5393	4258	2
59	3546	·438 1097	7313	·469 2147	5552	7481	7887	6726	1
60	6183	3711	9905	4716	8096	·500 0000	·515 0381	9193	0
′	65°	64°	63°	62°	61°	60°	59°	58°	′

NAT. COSINE.

′	32°	33°	34°	35°	36°	37°	38°	39°	′
0	·529 9193	·544 6390	·559 1929	·573 5764	·587 7853	·601 8150	·615 6615	·629 3204	60
1	·530 1659	8830	4340	8147	·588 0206	·602.0473	8907	5464	59
2	4125	·545 1269	6751	·574 0529	2558	2795	·616 1198	7724	58
3	6591	3707	9162	2911	4910	5117	3489	9983	57
4	9057	6145	·560 1572	5292	7262	7439	5780	·630 2242	56
5	·531 1521	8583	3981	7672	9613	9760	8069	4500	55
6	3986	·546 1020	6390	·575 0053	·589 1964	·603 2080	·617 0359	6758	54
7	6450	3456	8798	2432	4314	4400	2648	9015	53
8	8913	5892	·561 1206	4811	6663	6719	4936	·631 1272	52
9	·532 1370	8328	3614	7190	9012	9038	7224	3528	51
10	3839	·547 0763	6021	9568	·590 1361	.604 1356	9511	5784	50
11	6301	3198	8428	·576.1946	3709	3674	·618 1798	8039	49
12	8763	5632	·562 0834	4323	6057	5991	4084	·632 0293	48
13	·533 1224	8066	3239	6700	8404	8308	6370	2547	47
14	3685	·548 0499	5645	9076	·591 0750	·605 0624	8655	4800	46
15	6145	2932	8049	·577 1452	3096	2940	·619 0939	7053	45
16	8605	5365	·563 0453	3827	5442	5255	3224	9306	44
17	·534 1065	7797	2857	6202	7787	7570	5507	·633 1557	43
18	3523	·549 0228	5260	8576	·592 0132	9884	7790	3809	42
19	5982	2659	7663	·578 0950	2476	·606 2198	·620 0073	6059	41
20	8440	5090	·564 0066	3323	4819	4511	2355	8310	40
21	·535 0898	7520	2467	5696	7163	6824	4636	·634 0559	39
22	3355	9950	4869	8069	9505	9136	6917	2808	38
23	5812	·550 2379	7270	·579 0440	·593 1847	·607 1447	9198	5057	37
24	8268	4807	9670	2812	4189	3758	·621 1478	7305	36
25	·536 0724	7236	·565 2070	5183	6530	6069	3757	9553	35
26	3179	9663	4469	7553	8871	8379	6036	·635 1800	34
27	5634	·551 2091	6868	9923	·594 1211	·608 0689	8314	4046	33
28	8089	4518	9267	·580 2292	3550	2998	·622 0592	6292	32
29	·537 0543	6944	·566.1665	4661	5889	5306	2870	8537	31
30	2996	9370	4062	7030	8228	7614	5146	·636 0782	30
31	5449	·552 1795	6459	9397	·595 0566	9922	7423	3026	29
32	7902	4220	8856	·581 1765	2904	·609 2229	9698	5270	28
33	·538 0354	6645	·567 1252	4132	5241	4535	·623 1974	7513	27
34	2806	9069	3648	6498	7577	6841	4248	9756	26
35	5257	·553 1492	6043	8864	9913	9147	6522	·637 1998	25
36	7708	3915	8437	·582 1230	·596 2249	·610 1452	8796	4240	24
37	·539 0158	6338	·568 0832	3595	4584	3756	·624 1069	6481	23
38	2608	8760	3225	5959	6918	6060	3342	8721	22
39	5058	·554 1182	5619	8323	9252	8363	5614	·638 0961	21
40	7507	3603	8011	·583 0687	·597 1586	·611 0666	7885	3201	20
41	9955	6024	·569 0403	3050	3919	2969	·625 0156	5440	19
42	·540 2403	8444	2795	5412	6251	5270	2427	7678	18
43	4851	·555 0864	5187	7774	8583	7572	4696	9916	17
44	7298	3283	7577	·584 0136	·598 0915	9873	6966	·639 2153	16
45	9745	5702	9968	2497	3246	·612 2173	9235	4390	15
46	·541 2191	8121	·570 2357	4857	5577	4473	·626 1503	6626	14
47	4637	·556 0539	4747	7217	7906	6772	3771	8862	13
48	7082	2956	7136	9577	·599 0236	9071	6038	·640 1097	12
49	9527	5373	9524	·585 1936	2565	·613 1369	8305	3332	11
50	·542 1971	7790	·571 1912	4294	4893	3666	·627 0571	5566	10
51	4415	·557 0206	4299	6652	7221	5964	2837	7799	9
52	6859	2621	6686	9010	9549	8260	5102	·641 0032	8
53	9302	5036	9073	·586 1367	·600 1876	·614 0556	7366	2264	7
54	·543 1744	7451	·572 1459	3724	4202	2852	9631	4496	6
55	4187	9865	3844	6080	6528	5147	·628 1894	6728	5
56	6628	·558 2279	6229	8435	8854	7442	4157	8958	4
57	9069	4692	8614	·587 0790	·601 1179	9736	6420	·642 1189	3
58	·544 1510	7105	·573 0998	3145	3503	·615 2029	8682	3418	2
59	3951	9517	3381	5499	5827	4322	·629 0943	5647	1
60	6390	·559 1929	5764	7853	8150	6615	3204	7876	0
′	57°	56°	55°	54°	53°	52°	51°	50°	′

NAT. COSINE.

′	40°	41°	42°	43°	44°	45°	46°	47°	′
0	·642 7876	·656 0590	·669 1306	·681 9984	·694 6584	·707 1068	·719 3398	·731 3537	60
1	·643 0104	2785	3468	·682 2111	8676	3124	5418	5521	59
2	2332	4980	5628	4237	·695 0767	5180	7438	7503	58
3	4559	7174	7789	6363	2858	7236	9457	9486	57
4	6785	9367	9948	8489	4949	9291	·720 1476	·732 1467	56
5	9011	·657 1560	·670 2108	·683 0613	7039	·708 1345	3494	3449	55
6	·644 1236	3752	4266	2738	9128	3398	5511	5429	54
7	3461	5944	6424	4861	·696 1217	5451	7528	7409	53
8	5685	8135	8582	6984	3305	7504	9544	9388	52
9	7909	·658 0326	·671 0739	9107	5392	9556	·721 1559	·733 1367	51
10	·645 0132	2516	2895	·684 1229	7479	·709 1607	3574	3345	50
11	2355	4706	5051	3350	9565	3657	5589	5322	49
12	4577	6895	7206	5471	·697 1651	5707	7602	7299	48
13	6798	9083	9361	7591	3736	7757	9615	9275	47
14	9019	·659 1271	·672 1515	9711	5821	9806	·722 1628	·734 1250	46
15	·646 1240	3458	3668	·685 1830	7905	·710 1854	3640	3225	45
16	3460	5645	5821	3948	9988	3901	5651	5199	44
17	5679	7831	7973	6066	·698 2071	5948	7661	7173	43
18	7898	·660 0017	·673 0125	8184	4153	7995	9671	9146	42
19	·647 0116	2202	2276	·686 0300	6234	·711 0041	·723 1681	·735 1118	41
20	2334	4386	4427	2416	8315	2086	3690	3090	40
21	4551	6570	6577	4532	·699 0396	4130	5698	5061	39
22	6767	8754	8727	6647	2476	6174	7705	7032	38
23	8984	·661 0936	·674 0876	8761	4555	8218	9712	9002	37
24	·648 1199	3119	3024	·687 0875	6633	·712 0260	·724 1719	·736 0971	36
25	3414	5300	5172	2988	8711	2303	3724	2940	35
26	5628	7482	7319	5101	·700 0789	4344	5729	4908	34
27	7842	9662	9466	7213	2866	6385	7734	6875	33
28	·649 0056	·662 1842	·675 1612	9325	4942	8426	9738	8842	32
29	2268	4022	3757	·688 1435	7018	·713 0465	·725 1741	·737 0808	31
30	4480	6200	5902	3546	9093	2504	3744	2773	30
31	6692	8379	8046	5655	·701 1167	4543	5746	4738	29
32	8903	·663 0557	·676 0190	7765	3241	6581	7747	6703	28
33	·650 1114	2734	2333	9873	5314	8618	9748	8666	27
34	3324	4910	4476	·689 1981	7387	·714 0655	·726 1748	·738 0629	26
35	5533	7087	6618	4089	9459	2691	3748	2592	25
36	7742	9262	8760	6195	·702 1531	4727	5747	4553	24
37	9951	·664 1437	·677 0901	8302	3601	6762	7745	6515	23
38	·651 2158	3612	3041	·690 0407	5672	8796	9743	8475	22
39	4366	5785	5181	2512	7741	·715 0830	·727 1740	·739 0435	21
40	6572	7959	7320	4617	9811	2863	3736	2394	20
41	8778	·665 0131	9459	6721	·703 1879	4895	5732	4353	19
42	·652 0984	2304	·678 1597	8824	3947	6927	7728	6311	18
43	3189	4475	3734	·691 0927	6014	8959	9722	8268	17
44	5394	6646	5871	3029	8081	·716 0989	·728 1716	·740 0225	16
45	7598	8817	8007	5131	·704 0147	3019	3710	2181	15
46	9801	·666 0987	·679 0143	7232	2213	5049	5703	4137	14
47	·653 2004	3156	2278	9332	4278	7078	7695	6092	13
48	4206	5325	4413	·692 1432	6342	9106	9686	8046	12
49	6408	7493	6547	3531	8406	·717·1134	·729 1677	·741 0000	11
50	8609	9661	8681	5630	·705 0469	3161	3668	1953	10
51	·654 0810	·667 1828	·680 0813	7728	2532	5187	5657	3905	9
52	3010	3994	2946	9825	4594	7213	7646	5857	8
53	5209	6160	5078	·693 1922	6655	9238	9635	7808	7
54	7408	8326	7209	4018	8716	·718 1263	·730 1623	9758	6
55	9607	·668 0490	9339	6114	·706 0776	3287	3610	·742 1708	5
56	·655 1804	2655	·681 1469	8209	2835	5310	5597	3658	4
57	4002	4818	3599	·694 0304	4894	7333	7583	5606	3
58	6198	6981	5728	2398	6953	9355	9568	7554	2
59	8395	9144	7856	4491	9011	·719 1377	·731 1553	9502	1
60	·656 0590	·669 1306	9984	6584	·707 1068	3398	3537	·743 1448	0
′	49°	48°	47°	46°	45°	44°	43°	42°	′

NAT. COSINE

NATURAL SINES.

′	48°	49°	50°	51°	52°	53°	54°	′
0	·743 1448	·754 7096	·766 0444	·777 1460	·788 0108	·798 6355	·809 0170	60
1	3394	9004	2314	3290	1898	8105	1879	59
2	5340	·755 0911	4183	5120	3688	9855	3588	58
3	7285	2818	6051	6949	5477	·799 1604	5296	57
4	9229	4724	7918	8777	7266	3352	7004	56
5	·744 1173	6630	9785	·778 0604	9054	5100	8710	55
6	3115	8535	·767 1652	2431	·789 0841	6847	·810 0416	54
7	5058	·756 0439	3517	4258	2627	8593	2122	53
8	6999	2342	5382	6084	4413	·800 0338	3826	52
9	8941	4246	7246	7909	6198	2083	5530	51
10	·745 0881	6148	9110	9733	7983	3827	7234	50
11	2821	8050	·768 0973	·779 1557	9767	5571	8936	49
12	4760	9951	2835	3380	·790 1550	7314	·811 0638	48
13	6699	·757 1851	4697	5202	3333	9056	2339	47
14	8636	3751	6558	7024	5115	·801 0797	4040	46
15	·746 0574	5650	8418	8845	6896	2538	5740	45
16	2510	7548	·769 0278	·780 0665	8676	4278	7439	44
17	4446	9446	2137	2485	·791 0456	6018	9137	43
18	6382	·758 1343	3996	4304	2235	7756	·812 0835	42
19	8317	3240	5853	6123	4014	9495	2532	41
20	·747 0251	5136	7710	7940	5792	·802 1232	4229	40
21	2184	7031	9567	9757	7569	2969	5925	39
22	4117	8926	·770 1423	·781 1574	9345	4705	7620	38
23	6049	·759 0820	3278	3390	·792 1121	6440	9314	37
24	7981	2713	5132	5205	2896	8175	·813 1008	36
25	9912	4606	6986	7019	4671	9909	2701	35
26	·748 1842	6498	8840	8833	6445	·803 1642	4393	34
27	3772	8389	·771 0692	·782 0646	8218	3375	6084	33
28	5701	·760 0280	2544	2459	9990	5107	7775	32
29	7629	2170	4395	4270	·793 1762	6838	9466	31
30	9557	4060	6246	6082	3533	8569	·814 1155	30
31	·749 1484	5949	8096	7892	5304	·804 0299	2844	29
32	3411	7837	9945	9702	7074	2028	4532	28
33	5337	9724	·772 1794	·783 1511	8843	3756	6220	27
34	7262	·761 1611	3642	3320	·794 0611	5484	7906	26
35	9187	3497	5489	5127	2379	7211	9593	25
36	·750 1111	5383	7336	6935	4146	8938	·815 1278	24
37	3034	7268	9182	8741	5913	·805 0664	2963	23
38	4957	9152	·773 1027	·784 0547	7678	2389	4647	22
39	6879	·762 1036	2872	2352	9444	4113	6330	21
40	8800	2919	4716	4157	·795 1208	5837	8013	20
41	·751 0721	4802	6559	5961	2972	7560	9695	19
42	2641	6683	8402	7764	4735	9283	·816 1376	18
43	4561	8564	·774 0244	9566	6497	·806 1005	3056	17
44	6480	·763 0445	2086	·785 1368	8259	2726	4736	16
45	8398	2325	3926	3169	·796 0020	4446	6416	15
46	·752 0316	4204	5767	4970	1780	6166	8094	14
47	2233	6082	7606	6770	3540	7885	9772	13
48	4149	7960	9445	8569	5299	9603	·817 1449	12
49	6065	9838	·775 1283	·786 0367	7058	·807 1321	3125	11
50	7980	·764 1714	3121	2165	8815	3038	4801	10
51	9894	3590	4957	8963	·797 0572	4754	6476	9
52	·753 1808	5465	6794	5759	2329	6470	8151	8
53	3721	7340	8629	7555	4084	8185	9824	7
54	5634	9214	·776 0464	9350	5839	9899	·818 1497	6
55	7546	·765 1087	2298	·787 1145	7594	·808 1612	3169	5
56	9457	2960	4132	2939	9347	3325	4841	4
57	·754 1368	4832	5965	4732	·798 1100	5037	6512	3
58	3278	6704	7797	6524	2853	6749	8182	2
59	5187	8574	9629	8316	4604	8460	9852	1
60	7096	·766 0444	·777 1460	·788 0108	6355	·809 0170	·819 1520	0
′	41°	40°	39°	38°	37°	36°	35°	′

NAT. COSINE.

′	55°	56°	57°	58°	59°	60°	61°	′
0	·819 1520	·829 0376	·838 6706	·848 0481	·857 1673	·866 0254	·874 6197	60
1	3189	2002	8290	2022	3171	1708	7607	59
2	4856	3628	9873	3562	4668	3161	9016	58
3	6523	5252	·839 1455	5102	6164	4614	·875 0425	57
4	8189	6877	3037	6641	7660	6066	1832	56
5	9854	8500	4618	8179	9155	7517	3239	55
6	·820 1519	·830 0123	6199	9717	·858 0649	8967	4645	54
7	3183	1745	7778	·849 1254	2143	·867 0417	6051	53
8	4846	3366	9357	2790	3635	1866	7455	52
9	6509	4987	·840 0936	4325	5127	3314	8859	51
10	8170	6607	2513	5860	6619	4762	·876 0263	50
11	9832	8226	4090	7394	8109	6209	1665	49
12	·821 1492	9845	5666	8927	9599	7655	3067	48
13	3152	·831 1463	7241	·850 0459	·859 1088	9100	4468	47
14	4811	3080	8816	1991	2576	·868 0544	5868	46
15	6469	4696	·841 0390	3522	4064	1988	7268	45
16	8127	6312	1963	5053	5551	3431	8666	44
17	9784	7927	3536	6582	7037	4874	·877 0064	43
18	·822 1440	9541	5108	8111	8523	6315	1462	42
19	3096	·832 1155	6679	9639	·860 0007	7756	2858	41
20	4751	2768	8249	·851 1167	1491	9196	4254	40
21	6405	4380	9819	2693	2975	·869 0636	5649	39
22	8059	5991	·842 1388	4219	4457	2074	7043	38
23	9712	7602	2956	5745	5939	3512	8437	37
24	·823 1364	9212	4524	7269	7420	4949	9830	36
25	3015	·833 0822	6091	8793	8901	6386	·878 1222	35
26	4666	2430	7657	·852 0316	·861 0380	7821	2613	34
27	6316	4038	9222	1839	1859	9256	4004	33
28	7965	5646	·843 0787	3360	3337	·870 0691	5394	32
29	9614	7252	2351	4881	4815	2124	6783	31
30	·824 1262	8858	3914	6402	6292	3557	8171	30
31	2909	·834 0463	5477	7921	7768	4989	9559	29
32	4556	2068	7039	9440	9243	6420	·879 0946	28
33	6202	3672	8600	·853 0958	·862 0717	7851	2332	27
34	7847	5275	·844 0161	2475	2191	9281	3717	26
35	9491	6877	1720	3992	3664	·871 0710	5102	25
36	·825 1135	8479	3279	5508	5137	2138	6486	24
37	2778	·835 0080	4838	7023	6608	3566	7869	23
38	4420	1680	6395	8538	8079	4993	9251	22
39	6062	3279	7952	·854 0051	9549	6419	·880 0633	21
40	7703	4878	9508	1564	·863 1019	7844	2014	20
41	9343	6476	·845 1064	3077	2488	9269	3394	19
42	·826 0983	8074	2618	4588	3956	·872 0693	4774	18
43	2622	9670	4172	6099	5423	2116	6152	17
44	4260	·836 1266	5726	7609	6889	3538	7530	16
45	5897	2862	7278	9119	8355	4960	8907	15
46	7534	4456	8830	·855 0627	9820	6381	·881 0284	14
47	9170	6050	·846 0381	2135	·864 1284	7801	1660	13
48	·827 0806	7643	1932	3643	2748	9221	3035	12
49	2440	9236	3481	5149	4211	·873 0640	4409	11
50	4074	·837 0827	5030	6655	5673	2058	5782	10
51	5708	2418	6579	8160	7134	3475	7155	9
52	7340	4009	8126	9664	8595	4891	8527	8
53	8972	5598	9673	·856 1168	·865 0065	6307	9898	7
54	·828 0603	7187	·847 1219	2671	1514	7722	·882 1269	6
55	2234	8775	2765	4173	2973	9137	2638	5
56	3864	·838 0363	4309	5674	4430	·874 0550	4007	4
57	5493	1950	5853	7175	5887	1963	5376	3
58	7121	3536	7397	8675	7344	3375	6743	2
59	8749	5121	8939	·857 0174	8799	4786	8110	1
60	·829 0376	6706	·848 0481	1673	·866 0254	6197	9476	0
′	34°	33°	32°	31°	30°	29°	28°	′

NAT. COSINE.

′	48°	49°	50°	51°	52°	53°	54°	′
0	·743 1448	·754 7096	·766 0444	·777 1460	·788 0108	·798 6355	·809 0170	60
1	3394	9004	2314	3290	1898	8105	1879	59
2	5340	·755 0911	4183	5120	3688	9855	3588	58
3	7285	2818	6051	6949	5477	·799 1604	5296	57
4	9229	4724	7918	8777	7266	3352	7004	56
5	·744 1173	6630	9785	·778 0604	9054	5100	8710	55
6	3115	8535	·767 1652	2431	·789 0841	6847	·810 0416	54
7	5058	·756 0439	3517	4258	2627	8593	2122	53
8	6999	2342	5382	6084	4413	·800 0338	3826	52
9	8941	4246	7246	7909	6198	2083	5530	51
10	·745 0881	6148	9110	9733	7983	3827	7234	50
11	2821	8050	·768 0973	·779 1557	9767	5571	8936	49
12	4760	9951	2835	3380	·790 1550	7314	·811 0636	48
13	6699	·757 1851	4697	5202	3333	9056	2339	47
14	8636	3751	6558	7024	5115	·801 0797	4040	46
15	·746 0574	5650	8418	8845	6896	2538	5740	45
16	2510	7548	·769 0278	·780 0665	8676	4278	7439	44
17	4446	9446	2137	2485	·791 0456	6018	9137	43
18	6382	·758 1343	3996	4304	2235	7756	·812 0835	42
19	8317	3240	5853	6123	4014	9495	2532	41
20	·747 0251	5136	7710	7940	5792	·802 1232	4229	40
21	2184	7031	9567	9757	7569	2969	5925	39
22	4117	8926	·770 1423	·781 1574	9345	4705	7620	38
23	6049	·759 0820	3278	3390	·792 1121	6440	9314	37
24	7981	2713	5132	5205	2896	8175	·813 1008	36
25	9912	4606	6986	7019	4671	9909	2701	35
26	·748 1842	6498	8840	8833	6445	·803 1642	4393	34
27	3772	8389	·771 0692	·782 0646	8218	3375	6084	33
28	5701	·760 0280	2544	2459	9990	5107	7775	32
29	7629	2170	4395	4270	·793 1762	6838	9466	31
30	9557	4060	6246	6082	3533	8569	·814 1155	30
31	·749 1484	5949	8096	7892	5304	·804 0299	2844	29
32	3411	7837	9945	9702	7074	2028	4532	28
33	5337	9724	·772 1794	·783 1511	8843	3756	6220	27
34	7262	·761 1611	3642	3320	·794 0611	5484	7906	26
35	9187	3497	5489	5127	2379	7211	9593	25
36	·750 1111	5383	7336	6935	4146	8938	·815 1278	24
37	3034	7268	9182	8741	5913	·805 0664	2963	23
38	4957	9152	·773 1027	·784 0547	7678	2389	4647	22
39	6879	·762 1036	2872	2352	9444	4113	6330	21
40	8800	2919	4716	4157	·795 1208	5837	8013	20
41	·751 0721	4802	6559	5961	2972	7560	9695	19
42	2641	6683	8402	7764	4735	9283	·816 1376	18
43	4561	8564	·774 0244	9566	6497	·806 1005	3056	17
44	6480	·763 0445	2086	·785 1368	8259	2726	4736	16
45	8398	2325	3926	3169	·796 0020	4446	6416	15
46	·752 0316	4204	5767	4970	1780	6166	8094	14
47	2233	6082	7606	6770	3540	7885	9772	13
48	4149	7960	9445	8569	5299	9603	·817 1449	12
49	6065	9838	·775 1283	·786 0367	7058	·807 1321	3125	11
50	7980	·764 1714	3121	2165	8815	3038	4801	10
51	9894	3590	4957	8963	·797 0572	4754	6476	9
52	·753 1808	5465	6794	5759	2329	6470	8151	8
53	3721	7340	8629	7555	4084	8185	9824	7
54	5634	9214	·776 0464	9350	5839	9899	·818 1497	6
55	7546	·765 1087	2298	·787 1145	7594	·808 1612	3169	5
56	9457	2960	4132	2939	9347	3325	4841	4
57	·754 1368	4832	5965	4732	·798 1100	5037	6512	3
58	3278	6704	7797	6524	2853	6749	8182	2
59	5187	8574	9629	8316	4604	8460	9852	1
60	7096	·766 0444	·777 1460	·788 0108	6355	·809 0170	·819 1520	0
′	41°	40°	39°	38°	37°	36°	35°	′

NAT. COSINE.

′	55°	56°	57°	58°	59°	60°	61°	′
0	·819 1520	·829 0376	·838 6706	·848 0481	·857 1673	·866 0254	·874 6197	60
1	3189	2002	8290	2022	3171	1708	7607	59
2	4856	3628	9873	3562	4668	3161	9016	58
3	6523	5252	·839 1455	5102	6164	4614	·875 0425	57
4	8189	6877	3037	6641	7660	6066	1832	56
5	9854	8500	4618	8179	9155	7517	3239	55
6	·820 1519	·830 0123	6199	9717	·858 0649	8967	4645	54
7	3183	1745	7778	·849 1254	2143	·867 0417	6051	53
8	4846	3366	9357	2790	3635	1866	7455	52
9	6509	4987	·840 0936	4325	5127	3314	8859	51
10	8170	6607	2513	5860	6619	4762	·876 0263	50
11	9832	8226	4090	7394	8109	6209	1665	49
12	·821 1492	9845	5666	8927	9599	7655	3067	48
13	3152	·831 1463	7241	·850 0459	·859 1088	9100	4468	47
14	4811	3080	8816	1991	2576	·868 0544	5868	46
15	6469	4696	·841 0390	3522	4064	1988	7268	45
16	8127	6312	1963	5053	5551	3431	8666	44
17	9784	7927	3536	6582	7037	4874	·877 0064	43
18	·822 1440	9541	5108	8111	8523	6315	1462	42
19	3096	·832 1155	6679	9639	·860 0007	7756	2858	41
20	4751	2768	8249	·851 1167	1491	9196	4254	40
21	6405	4380	9819	2693	2975	·869 0636	5649	39
22	8059	5991	·842 1388	4219	4457	2074	7043	38
23	9712	7602	2956	5745	5939	3512	8437	37
24	·823 1364	9212	4524	7269	7420	4949	9830	36
25	3015	·833 0822	6091	8793	8901	6386	·878 1222	35
26	4666	2430	7657	·852 0316	·861 0380	7821	2613	34
27	6316	4038	9222	1839	1859	9256	4004	33
28	7965	5646	·843 0787	3360	3337	·870 0691	5394	32
29	9614	7252	2351	4881	4815	2124	6783	31
30	·824 1262	8858	3914	6402	6292	3557	8171	30
31	2909	·834 0463	5477	7921	7768	4989	9559	29
32	4556	2068	7039	9440	9243	6420	·879 0946	28
33	6202	3672	8600	·853 0958	·862 0717	7851	2332	27
34	7847	5275	·844 0161	2475	2191	9281	3717	26
35	9491	6877	1720	3992	3664	·871 0710	5102	25
36	·825 1135	8479	3279	5508	5137	2138	6486	24
37	2778	·835 0080	4838	7023	6608	3566	7869	23
38	4420	1680	6395	8538	8079	4993	9251	22
39	6062	3279	7952	·854 0051	9549	6419	·880 0633	21
40	7703	4878	9508	1564	·863 1019	7844	2014	20
41	9343	6476	·845 1064	3077	2488	9269	3394	19
42	·826 0983	8074	2618	4588	3956	·872 0693	4774	18
43	2622	9670	4172	6099	5423	2116	6152	17
44	4260	·836 1266	5726	7609	6889	3538	7530	16
45	5897	2862	7278	9119	8355	4960	8907	15
46	7534	4456	8830	·855 0627	9820	6381	·881 0284	14
47	9170	6050	·846 0381	2135	·864 1284	7801	1660	13
48	·827 0806	7643	1932	3643	2748	9221	3035	12
49	2440	9236	3481	5149	4211	·873 0640	4409	11
50	4074	·837 0827	5030	6655	5673	2058	5782	10
51	5708	2418	6579	8160	7134	3475	7155	9
52	7340	4009	8126	9664	8595	4891	8527	8
53	8972	5598	9673	·856 1168	·865 0055	6307	9898	7
54	·828 0603	7187	·847 1219	2671	1514	7722	·882 1269	6
55	2234	8775	2765	4173	2973	9137	2638	5
56	3864	·838 0363	4309	5674	4430	·874 0550	4007	4
57	5493	1950	5853	7175	5887	1963	5376	3
58	7121	3536	7397	8675	7344	3375	6743	2
59	8749	5121	8939	·857 0174	8799	4786	8110	1
60	·829 0376	6706	·848 0481	1673	·866 0254	6197	9476	0
′	34°	33°	32°	31°	30°	29°	28°	′

NAT. COSINE.

′	62°	63°	64°	65°	66°	67°	68°	′
0	·882 9476	.891 0065	·898 7940	·906 3078	·913 5455	·920 5049	·927 1839	60
1	·883 0841	1385	9215	4307	6637	6185	2928	59
2	2206	2705	·899 0489	5535	7819	7320	4016	58
3	3569	4024	1763	6762	9001	8455	5104	57
4	4933	5342	3035	7989	·914 0181	9589	6191	56
5	6295	6659	4307	9215	1361	.921 0722	7277	55
6	7656	7975	5578	·907 0440	2540	1854	8363	54
7	9017	9291	6848	1665	3718	2986	9447	53
8	·884 0377	·892 0606	8117	2888	4895	4116	·928 0531	52
9	1736	1920	9386	4111	6072	5246	1614	51
10	3095	3234	·900 0654	5333	7247	6375	2696	50
11	4453	4546	1921	6554	8422	7504	3778	49
12	5810	5858	3188	7775	9597	8632	4858	48
13	7166	7169	4453	8995	·915 0770	9758	5938	47
14	8522	8480	5718	·908 0214	1943	·922 0884	7017	46
15	9876	9789	6982	1432	3115	2010	8096	45
16	·885 1230	·893 1098	8246	2649	4286	3134	9173	44
17	2584	2406	9508	3866	5456	4258	·929 0250	43
18	3936	3714	·901 0770	5082	6626	5381	1326	42
19	5288	5021	2031	6297	7795	6503	2401	41
20	6639	6326	3292	7511	8963	7624	3475	40
21	7989	7632	4551	8725	·916 0130	8745	4549	39
22	9339	8936	5810	9938	1297	9865	5622	38
23	·886 0688	·894 0240	7068	·909 1150	2462	·923 0984	6694	37
24	2036	1542	8325	2361	3627	2102	7765	36
25	3383	2844	9582	3572	4791	3220	8835	35
26	4730	4146	·902 0838	4781	5955	4336	9905	34
27	6075	5446	2092	5990	7118	5452	·930 0974	33
28	7420	6746	3347	7199	8279	6567	2042	32
29	8765	8045	4600	8406	9440	7682	3109	31
30	·887 0108	9344	5853	9613	·917 0601	8795	4176	30
31	1451	·895 0641	7105	·910 0819	1760	9908	5241	29
32	2793	1938	8356	2024	2919	·924 1020	6306	28
33	4134	3234	9606	3228	4077	2131	7370	27
34	5475	4529	·903 0856	4432	5234	3242	8434	26
35	6815	5824	2105	5635	6391	4351	9496	25
36	8154	7118	3353	6837	7546	5460	·931 0558	24
37	9492	8411	4600	8038	8701	6568	1619	23
38	·888 0830	9703	5847	9238	9855	7676	2679	22
39	2166	.896 0994	7093	·911 0438	·918 1009	8782	3739	21
40	3503	2285	8338	1637	2161	9888	4797	20
41	4838	3575	9582	2836	3313	·925 0993	5855	19
42	6172	4864	·904 0825	4033	4464	2097	6912	18
43	7506	6153	2068	5229	5614	3201	7969	17
44	8839	7440	3310	6425	6763	4303	9024	16
45	·889 0171	8727	4551	7620	7912	5405	·932 0079	15
46	1503	·897 0014	5792	8815	9060	6506	1133	14
47	2834	1299	7032	·912 0008	·919 0207	7606	2186	13
48	4164	2584	8271	1201	1353	8706	3238	12
49	5493	3868	9509	2393	2499	9805	4290	11
50	6822	5151	·905 0746	3584	3644	·926 0902	5340	10
51	8149	6433	1983	4775	4788	2000	6390	9
52	9476	7715	3219	5965	5931	3096	7439	8
53	·890 0803	8996	4454	7154	7073	4192	8488	7
54	2128	·898 0276	5688	8342	8215	5286	9535	6
55	3453	1555	6922	9529	9356	6380	·933 0582	5
56	4777	2834	8154	·913 0716	·920 0496	7474	1628	4
57	6100	4112	9386	1902	1635	8566	2673	3
58	7423	5389	·906 0618	3087	2774	9658	3718	2
59	8744	6665	1848	4271	3912	·927 0748	4761	1
60	·891 0065	7940	3078	5455	5049	1839	5804	0
′	27°	26°	25°	24°	23°	22°	21°	′

NAT. COSINE.

′	69°	70°	71°	72°	73°	74°	75°	′
0	·933 5804	·939 6926	·945 5186	·951 0565	·956 3048	·961 2617	·965 9258	60
1	6846	7921	6132	1464	3898	3418	·966 0011	59
2	7888	8914	7078	2361	4747	4219	0762	58
3	8928	9907	8023	3258	5595	5019	1513	57
4	9968	·940 0899	8968	4154	6443	5818	2263	56
5	·934 1067	1891	9911	5050	7290	6616	3012	55
6	2045	2881	·946 0854	5944	8136	7413	3761	54
7	3082	3871	1795	6838	8981	8210	4508	53
8	4119	4860	2736	7731	9825	9005	5255	52
9	5154	5848	3677	8623	·957 0669	9800	6001	51
10	6189	6835	4616	9514	1512	·962 0594	6746	50
11	7223	7822	5555	·952 0404	2354	1387	7490	49
12	8257	8808	6493	1294	3195	2180	8234	48
13	9289	9793	7430	2183	4035	2972	8977	47
14	·935 0321	·941 0777	8366	3071	4875	3762	9718	46
15	1352	1760	9301	3958	5714	4552	·967 0459	45
16	2382	2743	·947 0236	4844	6552	5342	1200	44
17	3412	3724	1170	5730	7389	6130	1939	43
18	4440	4705	2103	6615	8225	6917	2678	42
19	5468	5686	3035	7499	9060	7704	3415	41
20	6495	6665	3966	8382	9895	8490	4152	40
21	7521	7644	4897	9264	·958 0729	9275	4888	39
22	8547	8621	5827	·953 0146	1562	·963 0060	5624	38
23	9571	9598	6756	1027	2394	0843	6358	37
24	·936 0595	·942 0575	7684	1907	3226	1626	7092	36
25	1618	1550	8612	2786	4056	2408	7825	35
26	2641	2525	9538	3664	4886	3189	8557	34
27	3662	3498	·948 0464	4542	5715	3969	9288	33
28	4683	4471	1389	5418	6543	4748	·968 0018	32
29	5703	5444	2313	6294	7371	5527	0748	31
30	6722	6415	3237	7170	8197	6305	1476	30
31	7740	7386	4159	8044	9023	7081	2204	29
32	8758	8355	5081	8917	9848	7858	2931	28
33	9774	9324	6002	9790	·959 0672	8633	3658	27
34	·937 0790	·943 0293	6922	·954 0662	1496	9407	4383	26
35	1806	1260	7842	1533	2318	·964 0181	5108	25
36	2820	2227	8760	2403	3140	0954	5832	24
37	3833	3192	9678	3273	3961	1726	6555	23
38	4846	4157	·949 0595	4141	4781	2497	7277	22
39	5858	5122	1511	5009	5600	3268	7998	21
40	6869	6085	2426	5876	6418	4037	8719	20
41	7880	7048	3341	6743	7236	4806	9438	19
42	8889	8010	4255	7608	8053	5574	·969 0157	18
43	9898	8971	5168	8473	8869	6341	0875	17
44	·938 0906	9931	6080	9336	9684	7108	1593	16
45	1913	·944 0890	6991	·955 0199	·960 0499	7873	2309	15
46	2920	1849	7902	1062	1312	8638	3025	14
47	3925	2807	8812	1923	2125	9402	3740	13
48	4930	3764	9721	2784	2937	·965 0165	4453	12
49	5934	4720	·950 0629	3648	3748	0927	5167	11
50	6938	5675	1536	4502	4558	1689	5879	10
51	7940	6630	2443	5361	5368	2449	6591	9
52	8942	7584	3348	6218	6177	3209	7301	8
53	9943	8537	4253	7074	6984	3968	8011	7
54	·939 0943	9489	5157	7930	7792	4726	8720	6
55	1942	·945 0441	6061	8785	8598	5484	9428	5
56	2940	1391	6963	9639	9403	6240	·970 0135	4
57	3938	2341	7865	·956 0492	·961 0208	6996	0842	3
58	4935	3290	8766	1345	1012	7751	1548	2
59	5931	4238	9666	2197	1815	8505	2253	1
60	6926	5186	·951 0565	3048	2617	9258	2957	0
′	20°	19°	18°	17°	16°	15°	14°	′

NAT. COSINE.

′	76°	77°	78°	79°	80°	81°	82°	′
0	·970 2957	·974 3701	·978 1476	·981 6272	·9848 078	·9876 883	·9902 681	60
1	3660	4355	2080	6826	582	·9877 338	·9903 085	59
2	4363	5008	2684	7380	·9849 086	792	489	58
3	5065	5660	3287	7933	589	·9878 245	891	57
4	5766	6311	3889	8485	·9850 091	697	·9904 293	56
5	6466	6962	4490	9037	593	·9879 148	694	55
6	7165	7612	5090	9587	·9851 093	599	·9905 095	54
7	7863	8261	5689	·982 0137	593	·9880 048	494	53
8	8561	8909	6288	0686	·9852 092	497	893	52
9	9258	9556	6886	1234	590	945	·9906 290	51
10	9953	·975 0203	7483	1781	·9853 087	·9881 392	687	50
11	·971 0649	0849	8079	2327	583	838	·9907 083	49
12	1343	1494	8674	2873	·9854 079	·9882 284	478	48
13	2036	2138	9268	3417	574	728	873	47
14	2729	2781	9862	3961	·9855 068	·9883 172	·9908 266	46
15	3421	3423	·979 0455	4504	561	615	659	45
16	4112	4065	1047	5046	·9856 053	·9884 057	·9909 051	44
17	4802	4706	1638	5587	544	498	442	43
18	5491	5345	2228	6128	·9857 035	939	832	42
19	6180	5985	2818	6668	524	·9885 378	·9910 221	41
20	6867	6623	3406	7206	·9858 013	817	610	40
21	7554	7260	3994	7744	501	·9886 255	997	39
22	8240	7897	4581	8282	988	692	·9911 384	38
23	8926	8533	5167	8818	·9859 475	·9887 128	770	37
24	9610	9168	5752	9353	960	564	·9912 155	36
25	·972 0294	9802	6337	9888	·9860 445	998	540	35
26	0976	·976 0435	6921	·983 0422	929	·9888 432	923	34
27	1658	1067	7504	0955	·9861 412	865	·9913 306	33
28	2339	1699	8086	1487	894	·9889 297	688	32
29	3020	2330	8667	2019	·9862 375	728	·9914 069	31
30	3699	2960	9247	2549	856	·9890 159	449	30
31	4378	3589	9827	3079	·9863 336	588	828	29
32	5056	4217	·980 0405	3608	815	·9891 017	·9915 206	28
33	5733	4845	0983	4136	·9864 293	445	584	27
34	6409	5472	1560	4663	770	872	961	26
35	7084	6098	2136	5189	·9865 246	·9892 298	·9916 337	25
36	7759	6723	2712	5715	722	723	712	24
37	8432	7347	3286	6239	·9866 196	·9893 148	·9917 086	23
38	9105	7970	3860	6763	670	572	459	22
39	9777	8593	4433	7286	·9867 143	994	832	21
40	·973 0449	9215	5005	7808	615	·9894 416	·9918 204	20
41	1119	9836	5576	8330	·9868 087	838	574	19
42	1789	·977 0456	6147	8850	557	·9895 258	944	18
43	2458	1075	6716	9370	·9869 027	677	·9919 314	17
44	3125	1693	7285	9889	496	·9896 096	682	16
45	3793	2311	7853	·984 0407	964	514	·9920 049	15
46	4458	2928	8420	0924	·9870 431	931	416	14
47	5124	3544	8986	1441	897	·9897 347	782	13
48	5789	4159	9552	1956	·9871 363	762	·9921 147	12
49	6453	4773	·981 0116	2471	827	·9898 177	511	11
50	7116	5386	0680	2985	·9872 291	590	874	10
51	7778	5999	1243	3498	754	·9899 003	·9922 237	9
52	8439	6611	1805	4010	·9873 216	415	599	8
53	9100	7222	2366	4521	678	826	959	7
54	9760	7832	2927	5032	·9874 138	·9900 237	·9923 319	6
55	·974 0419	8441	3486	5542	598	646	679	5
56	1077	9050	4045	6050	·9875 057	·9901 055	·9924 037	4
57	1734	9658	4603	6558	514	462	394	3
58	2390	·978 0265	5160	7066	972	869	751	2
59	3046	0871	5716	7572	·9876 428	·9902 275	·9925 107	1
60	3701	1476	6272	8078	883	681	462	0
′	13°	12°	11°	10°	9°	8°	7°	′

NAT. COSINE.

′	83°	84°	85°	86°	87°	88°	89°	′
0	·9925 462	·9945 219	·9961 947	·9975 641	·9986 295	·9993 908	·9998 477	60
1	816	523	·9962 200	843	447	·9994 009	527	59
2	·9926 169	825	452	·9976 045	598	110	577	58
3	521	·9946 127	704	245	748	209	625	57
4	873	428	954	445	898	308	673	56
5	·9927 224	729	·9963 204	645	·9987 046	405	720	55
6	573	·9947 028	453	843	194	502	766	54
7	922	327	701	·9977 040	340	598	812	53
8	·9928 271	625	948	237	486	693	856	52
9	618	921	·9964 195	433	631	788	900	51
10	965	·9948 217	440	627	775	881	942	50
11	·9929 310	513	685	821	919	974	984	49
12	655	807	929	·9978 015	·9988 061	·9995 066	·9999 025	48
13	999	·9949 101	·9965 172	207	203	157	065	47
14	·9930 342	393	414	399	344	247	105	46
15	685	685	655	589	484	336	143	45
16	·9931 026	976	895	779	623	424	181	44
17	367	·9950 266	·9966 135	968	761	512	218	43
18	706	556	374	·9979 156	899	599	254	42
19	·9932 045	844	612	343	·9989 035	684	289	41
20	384	·9951 132	849	530	171	770	323	40
21	721	419	·9967 085	716	306	854	357	39
22	·9933 057	705	321	900	440	937	389	38
23	393	990	555	·9980 084	573	·9996 020	421	37
24	728	·9952 274	789	267	706	101	452	36
25	·9934 062	557	·9968 022	450	837	182	482	35
26	395	840	254	631	968	262	511	34
27	727	·9953 122	485	811	·9990 098	341	539	33
28	·9935 058	403	715	991	227	419	567	32
29	389	683	945	·9981 170	355	497	593	31
30	719	962	·9969 173	348	482	573	619	30
31	·9936 047	·9954 240	401	525	609	649	644	29
32	375	517	628	701	734	724	668	28
33	703	794	854	877	859	798	692	27
34	·9937 029	·9955 070	·9970 080	·9982 052	983	871	714	26
35	355	345	304	225	·9991 106	943	736	25
36	679	620	528	398	228	·9997 015	756	24
37	·9938 003	893	750	570	350	086	776	23
38	326	·9956 165	972	742	470	156	795	22
39	648	437	·9971 193	912	590	224	813	21
40	969	708	413	·9983 082	709	292	831	20
41	·9939 290	978	633	250	827	360	847	19
42	610	·9957 247	851	418	944	426	863	18
43	928	515	·9972 069	585	·9992 060	492	878	17
44	·9940 246	783	286	751	176	556	892	16
45	563	·9958 049	502	917	290	620	905	15
46	880	315	717	·9984 081	404	683	917	14
47	·9941 196	580	931	245	517	745	928	13
48	510	844	·9973 145	408	629	807	939	12
49	823	·9959 107	357	570	740	867	949	11
50	·9942 136	370	569	731	851	927	958	10
51	448	631	780	891	960	986	966	9
52	760	892	990	·9985 050	·9993 069	·9998 044	973	8
53	·9943 070	·9960 152	·9974 199	209	177	101	979	7
54	379	411	408	367	284	157	985	6
55	688	669	615	524	390	213	989	5
56	996	926	822	680	495	267	993	4
57	·9944 303	·9961 183	·9975 028	835	600	321	996	3
58	609	438	233	989	704	374	998	2
59	914	693	437	·9986 143	806	426	1·0000 000	1
60	·9945 219	947	641	295	908	477	000	0
′	6°	5°	4°	3°	2°	1°	0°	′

NAT. COSINE.

NATURAL TANGENTS.

′	0°	1°	2°	3°	4°	5°	6°	7°	′
0	·000 0000	·017 4551	·034 9208	·052 4078	·069 9268	·087 4887	·105 1042	·122 7846	60
1	2909	7460	·035 2120	6995	·070 2191	7818	3983	·123 0798	59
2	5818	·018 0370	5033	9912	5115	·088 0749	6925	3752	58
3	8727	3280	7945	·053 2829	8038	3681	9866	6705	57
4	·001 1636	6190	·036 0858	5746	·071 0961	6612	·106 2808	9658	56
5	4544	9100	3771	8663	3885	9544	5750	·124 2612	55
6	7453	·019 2010	6683	·054 1581	6809	·089 2476	8692	5566	54
7	·002 0362	4920	9596	4498	9733	5408	·107 1634	8520	53
8	3271	7830	·037 2500	7416	·072 2657	8341	4576	·125 1474	52
9	6180	·020 0740	5422	·055 0333	5581	·090 1273	7519	4429	51
10	9089	3650	8335	3251	8505	4200	·108 0462	7384	50
11	·003 1998	6560	·038 1248	6169	·073 1430	7138	3405	·126 0339	49
12	4907	9470	4161	9087	4354	·091 0071	6348	3294	48
13	7816	·021 2380	7074	·056 2005	7279	3004	9291	6249	47
14	·004 0725	5291	9988	4923	·074 0203	5938	·109 2234	9205	46
15	3634	8201	·039 2901	7841	3128	8871	5178	·127 2161	45
16	6542	·022 1111	5814	·057 0759	6053	·092 1804	8122	5117	44
17	9451	4021	8728	3678	8979	4738	·110 1066	8073	43
18	·005 2360	6932	·040 1641	6596	·075 1904	7672	4010	·128 1030	42
19	5269	9842	4555	9515	4829	·093 0606	6955	3986	41
20	8178	·023 2753	7469	·058 2434	7755	3540	9899	6943	40
21	·006 1087	5663	·041 0383	5352	·076 0680	6474	·111 2844	9900	39
22	3996	8574	3296	8271	3606	9409	5789	·129 2858	38
23	6905	·024 1484	6210	·059 1190	6532	·094 2344	8734	5815	37
24	9814	4395	9124	4109	9458	5278	·112 1680	8773	36
25	·007 2723	7305	·042 2038	7029	·077 2384	8213	4625	·130 1731	35
26	5632	·025 0216	4952	9948	5311	·095 1148	7571	4690	34
27	8541	3127	7866	·060 2867	8237	4084	·113 0517	7648	33
28	·008 1450	6038	·043 0781	5787	·078 1164	7019	3463	·131 0607	32
29	4360	8948	3695	8706	4090	9955	6410	3566	31
30	7269	·026 1859	6609	·061 1626	7017	·096 2890	9356	6525	30
31	·009 0178	4770	9524	4546	9944	5826	·114 2303	9484	29
32	3087	7681	·044 2438	7466	·079 2871	8763	5250	·132 2444	28
33	5996	·027 0592	5353	·062 0386	5798	·097 1699	8197	5404	27
34	8905	3503	8268	3306	8726	4635	·115 1144	8364	26
35	·010 1814	6414	·045 1183	6226	·080 1653	7572	4092	·133 1324	25
36	4724	9325	4097	9147	4581	·098 0509	7039	4285	24
37	7633	·028 2236	7012	·063 2067	7509	3446	9987	7246	23
38	·011 0542	5148	9927	4988	·081 0437	6383	·116 2936	·134 0207	22
39	3451	8059	·046 2842	7908	3365	9320	5884	3168	21
40	6361	·029 0970	5757	·064 0829	6293	·099 2257	8832	6129	20
41	9270	3882	8673	3750	9221	5194	·117 1781	9091	19
42	·012 2179	6793	·047 1588	6671	·082 2150	8133	4730	·135 2053	18
43	5088	9705	4503	9592	5078	·100 1071	7679	5015	17
44	7998	·030 2616	7419	·065 2513	8007	4009	·118 0628	7978	16
45	·013 0907	5528	·048 0334	5435	·083 0936	6947	3578	·136 0940	15
46	3817	8439	3250	8356	3865	9886	6528	3903	14
47	6726	·031 1351	6166	·066 1278	6794	·101 2824	9478	6866	13
48	9635	4263	9082	4199	9723	5763	·119 2428	9830	12
49	·014 2545	7174	·049 1997	7121	·084 2653	8702	5378	·137 2793	11
50	5454	·032 0086	4913	·067 0043	5583	·102 1641	8329	5757	10
51	8364	2998	7829	2965	8512	4580	·120 1279	8721	9
52	·015 1273	5910	·050 0746	5887	·085 1442	7520	4230	·138 1685	8
53	4183	8822	3662	8809	4372	·103 0460	7182	4650	7
54	7093	·033 1734	6578	·068 1732	7302	3399	·121 0133	7615	6
55	·016 0002	4646	9495	4654	·086 0233	6340	3085	·139 0580	5
56	2912	7558	·051 2411	7577	3163	9280	6036	3545	4
57	5821	·034 0471	5328	·069 0499	6094	·104 2220	8988	6510	3
58	8731	3383	8244	3422	9025	5161	·122 1941	9476	2
59	·017 1641	6295	·052 1161	6345	·087 1956	8101	4893	·140 2442	1
60	4551	9208	4078	9268	4887	·105 1042	7846	5408	0
′	89°	88°	87°	86°	85°	84°	83°	82°	′

NAT. COTAN

′	8°	9°	10°	11°	12°	13°	14°	15°	′
0	·140 5408	·158 3844	.176 3270	·194 3803	·212 5566	·230 8682	·249 3280	·267 9492	60
1	8375	6826	6269	6822	8606	·231 1746	6370	·268 2610	59
2	·141 1342	9809	9269	9841	·213 1647	4811	9460	5728	58
3	4308	·159 2791	·177 2269	·195 2861	4688	7876	·250 2551	8847	57
4	7276	5774	5270	5881	7730	·232 0941	5642	·269 1967	56
5	·142 0243	8757	8270	8901	·214 0772	4007	8734	5087	55
6	3211	·160 1740	·178 1271	·196 1922	3814	7073	·251 1826	8207	54
7	6179	4724	4273	4943	6857	·233 0140	4919	·270 1328	53
8	9147	7708	7274	7964	9900	3207	8012	4449	52
9	·143 2115	·161 0692	·179 0276	·197 0986	·215 2944	6274	·252 1106	7571	51
10	5084	3677	3279	4008	5988	9342	4200	·271 0694	50
11	8053	6662	6281	7031	9032	·234 2410	7294	3817	49
12	·144 1022	9647	9284	·198 0053	·216 2077	5479	·253 0389	6940	48
13	3991	·162 2632	·180 2287	3076	5122	8548	3484	·272 0064	47
14	6961	5618	5291	6100	8167	·235 1617	6580	3188	46
15	9931	8603	8295	9124	·217 1213	4687	9676	6313	45
16	·145 2901	·163 1590	·181 1299	·199 2148	4259	7758	·254 2773	9438	44
17	5872	4576	4303	5172	7306	·236 0829	5870	·273 2564	43
18	8842	7563	7308	8197	·218 0353	3900	8968	5690	42
19	·146 1813	·164 0550	·182 0313	·200 1222	3400	6971	·255 2066	8817	41
20	4784	3537	3319	4248	6448	·237 0044	5165	·274 1945	40
21	7756	6525	6324	7274	9496	3116	8264	5072	39
22	·147 0727	9513	9330	·201 0300	·219 2544	6189	·256 1363	8201	38
23	3699	·165 2501	·183 2337	3327	5593	9262	4463	·275 1330	37
24	6672	5489	5343	6354	8643	·238 2336	7564	4459	36
25	9644	8478	8350	9381	·220 1692	5410	·257 0664	7589	35
26	·148 2617	·166 1467	·184 1358	·202 2409	4742	8485	3766	·276 0719	34
27	5590	4456	4365	5437	7793	·239 1560	6868	3850	33
28	8563	7446	7373	8465	·221 0844	4635	9970	6981	32
29	·149 1536	·167 0436	·185 0382	·203 1494	3895	7711	·258 3073	·277 0113	31
30	4510	3426	3390	4523	6947	·240 0788	6176	3245	30
31	7484	6417	6399	7552	9999	3864	9280	6378	29
32	·150 0458	9407	9409	·204 0582	·222 3051	6942	·259 2384	9512	28
33	3433	·168 2398	·186 2418	3612	6104	·241 0019	5488	·278 2646	27
34	6408	5390	5428	6643	9157	3097	8593	5780	26
35	9383	8381	8439	9674	·223 2211	6176	·260 1699	8915	25
36	·151 2358	·169 1373	·187 1449	·205 2705	5265	9255	4805	·279 2050	24
37	5333	4366	4460	5737	8319	·242 2334	7911	5186	23
38	8309	7358	7471	8769	·224 1374	5414	·261 1018	8322	22
39	·152 1285	·170 0351	·188 0483	·206 1801	4429	8494	4126	·280 1459	21
40	4262	3344	3495	4834	7485	·243 1575	7234	4597	20
41	7238	6338	6507	7867	·225 0541	4656	·262 0342	7735	19
42	·153 0215	9331	9520	·207 0900	3597	7737	3451	·281 0873	18
43	3192	·171 2325	·189 2533	3934	6654	·244 0819	6560	4012	17
44	6170	5320	5546	6968	9711	3902	9670	7152	16
45	9147	8314	8559	·208 0003	·226 2769	6984	·263 2780	·282 0292	15
46	154 2125	·172 1309	·190 1573	3038	5827	·245 0068	5891	3432	14
47	5103	4304	4587	6073	8885	3151	9002	6573	13
48	8082	7300	7602	9109	·227 1944	6236	·264 2114	9715	12
49	·155 1061	·173 0296	·191 0617	·209 2145	5003	9320	5226	·283 2857	11
50	4040	3292	3632	5181	8063	·246 2405	8339	5999	10
51	7019	6288	6648	8218	·228 1123	5491	·265 1452	9143	9
52	9998	9285	9664	·210 1255	4184	8577	4566	·284 2286	8
53	·156 2978	·174 2282	·192 2680	4293	7244	·247 1663	7680	5430	7
54	5958	5279	5696	7331	·229 0306	4750	·266 0794	8575	6
55	8939	8277	8713	·211 0369	3367	7837	3909	·285 1720	5
56	·157 1919	·175 1275	·193 1731	3407	6429	·248 0925	7025	4866	4
57	4900	4273	4748	6446	9492	4013	·267 0141	8012	3
58	7881	7272	7766	9486	·230 2555	7102	3257	·286 1159	2
59	·158 0863	·176 0271	·194 0784	·212 2525	5618	·249 0191	6374	4306	1
60	3844	3270	3803	5566	8682	3280	9492	7454	0
′	81°	80°	79°	78°	77°	76°	75°	74°	′

NAT. COTAN.

′	16°	17°	18°	19°	20°	21°	22°	23°	′
0	·286 7454	·305 7307	·324 9197	·344 3276	·363 9702	·383 8640	·404 0262	·424 4748	60
1	·287 0602	·306 0488	·325 2413	6530	·364 2997	·384 1978	3646	8182	59
2	3751	3670	5630	9785	6292	5317	7031	·425 1616	58
3	6900	6852	8848	·345 3040	9588	8656	·405 0417	5051	57
4	·288 0050	·307 0034	·326 2066	6296	·365 2885	·385 1996	3804	8487	56
5	3201	3218	5284	9553	6182	5337	7191	·426 1924	55
6	6352	6402	8504	·346 2810	9480	8679	·406 0579	5361	54
7	9503	9586	·327 1724	6068	·366 2779	·386 2021	3968	8800	53
8	·289 2655	·308 2771	4944	9327	6079	5364	7358	·427 2239	52
9	5808	5957	8165	·347 2586	9379	8708	·407 0748	5680	51
10	8961	9143	·328 1387	5846	·367 2680	·387 2053	4139	9121	50
11	·290 2114	·309 2330	4610	9107	5981	5398	7531	·428 2563	49
12	5269	5517	7833	·348 2368	9284	8744	·408 0924	6005	48
13	8423	8705	·329 1056	5630	·368 2587	·388 2091	4318	9449	47
14	·291 1578	·310 1893	4281	8893	5890	5439	7713	·429 2894	46
15	4734	5083	7505	·349 2156	9195	8787	·409 1108	6339	45
16	7890	8272	·330 0731	5420	·369 2500	·389 2130	4504	9785	44
17	·292 1047	·311 1462	3957	8685	5800	5486	7901	·430 3232	43
18	4205	4653	7184	·350 1950	9112	8837	·410 1299	6680	42
19	7363	7845	·331 0411	5216	·370 2420	·390 2189	4697	·431 0129	41
20	·293 0521	·312 1036	3639	8483	5728	5541	8097	3579	40
21	3680	4229	6868	·351 1750	9036	8894	·411 1497	7030	39
22	6839	7422	·332 0097	5018	·371 2346	·391 2247	4898	·432 0481	38
23	9999	·313 0616	3327	8287	5656	5602	8300	3933	37
24	·294 3160	3810	6557	·352 1556	8967	8957	·412 1703	7386	36
25	6321	7005	9788	4826	·372 2278	·392 2313	5106	·433 0840	35
26	9483	·314 0200	·333 3020	8096	5590	5670	8510	4295	34
27	·295 2645	3396	6252	·353 1368	8903	9027	·413 1915	7751	33
28	5808	6593	9485	4640	.373 2217	·393 2386	5321	·434 1208	32
29	8971	9790	·334 2719	7912	5532	5745	8728	4665	31
30	·296 2135	·315 2988	5953	·354 1186	8847	9105	·414 2136	8124	30
31	5299	6186	9188	4460	·374 2163	·394 2465	5544	·435 1583	29
32	8464	9385	·335 2424	7734	5479	5827	8953	5043	28
33	·297 1630	·316 2585	5660	·355 1010	8797	9189	·415 2363	8504	27
34	4796	5785	8896	4286	·375 2115	·395 2552	5774	·436 1966	26
35	7962	8986	·336 2134	7562	5433	5916	9186	5429	25
36	·298 1129	·317 2187	5372	·356 0840	8753	9280	·416 2598	8893	24
37	4297	5389	8610	4118	·376 2073	·396 2645	6012	·437 2357	23
38	7465	8591	·337 1850	7397	5394	6011	9426	5823	22
39	·299 0634	·318 1794	5090	·357 0676	8716	9378	·417 2841	9289	21
40	3803	4998	8330	3956	·377 2038	·397 2746	6257	·438 2756	20
41	6973	8202	·338 1571	7237	5361	6114	9673	6224	19
42	·300 0144	·319 1407	4813	·358 0518	8685	9483	·418 3091	9693	18
43	3315	4613	8056	3801	·378 2010	·398 2853	6509	·439 3163	17
44	6486	7819	·339 1299	7083	5335	6224	9028	6634	16
45	9658	·320 1025	4543	·359 0367	8661	9595	·419 3348	·440 0105	15
46	·301 2831	4232	7787	3651	·379 1988	·399 2908	6769	3578	14
47	6004	7440	·340 1032	6936	5315	6341	·420 0190	7051	13
48	9178	·321 0649	4278	·360 0222	8644	9715	3613	·441 0526	12
49	·302 2352	3858	7524	3508	·380 1973	·400 3089	7036	4001	11
50	5527	7067	.341 0771	6795	5302	6465	·421 0460	7477	10
51	8703	·322 0278	4019	·361 0082	8633	9841	3885	·442 0954	9
52	·303 1879	3489	7267	3371	·381 1964	.401 3218	7311	4432	8
53	5055	6700	·342 0516	6660	5296	6596	·422 0738	7910	7
54	8232	9912	3765	9949	8629	9974	4165	·443 1390	6
55	·304 1410	·323 3125	7015	·362 3240	·382 1962	·402 3354	7594	4871	5
56	4588	6338	·343 0266	6531	5296	6734	·423 1023	8352	4
57	7767	9552	3518	9823	8631	·403 0115	4453	·444 1834	3
58	·305 0946	·324 2766	6770	·363 3115	·383 1967	3496	7884	5318	2
59	4126	5981	·344 0023	6408	5303	6879	·424 1316	8802	1
60	7307	9197	3276	9702	8640	·404 0262	4748	·445 2287	0
′	73°	72°	71°	70°	69°	68°	67°	66°	′

NAT. COTAN.

′	24°	25°	26°	27°	28°	29°	30°	31°	′
0	·445 2287	·466 3077	·487 7326	·509 5254	·531 7094	·554 3091	·577 3503	·600 8606	60
1	5773	6618	488 0927	8919	·532 0826	6894	7382	·601 2566	59
2	9260	·467 0161	4530	510 2585	4559	·555 0698	·578 1262	6527	58
3	·446 2747	3705	8133	6252	8293	4504	5144	·602 0490	57
4	6236	7250	·489 1737	9919	·533 2029	8311	9027	4454	56
5	9726	·468 0796	5343	·511 3588	5765	·556 2119	·579 2912	8419	55
6	·447 3216	4342	8949	7259	9503	5929	6797	·603 2386	54
7	6708	7890	·490 2557	·512 0930	·534 3242	9739	·580 0684	6354	53
8	·448 0200	·469 1439	6166	4602	6981	·557 3551	4573	·604 0323	52
9	3693	4988	9775	8275	·535 0723	7364	8462	4294	51
10	7187	8539	·491 3386	·513 1950	4465	·558 1179	·581 2353	8266	50
11	·449 0682	·470 2090	6997	5625	8208	4994	6245	·605 2240	49
12	4178	5643	·492 0610	9302	·536 1953	8811	·582 0139	6215	48
13	7675	9196	4224	·514 2980	5699	·559 2629	4034	·606 0192	47
14	·450 1173	·471 2751	7838	6658	9446	6449	7930	4170	46
15	4672	6306	·493 1454	·515 0338	·537 3194	·560 0269	·583 1828	8149	45
16	8171	9863	5071	4019	6943	4091	5726	·607 2130	44
17	·451 1672	·472 3420	8689	7702	·538 0694	7914	9627	6112	43
18	5173	6978	·494 2308	·516 1385	4445	·561 1738	·584 3528	·608 0095	42
19	8676	·473 0538	5928	5069	8198	5564	7431	4080	41
20	·452 2179	4098	9549	8755	·539 1952	9391	·585 1335	8067	40
21	5683	7659	·495 3171	·517 2441	5707	·562 3219	5241	·609 2054	39
22	9188	·474 1222	6794	6129	9464	7048	9148	6043	38
23	·453 2694	4785	·496 0418	9818	·540 3221	·563 0879	·586 3056	·610 0034	37
24	6201	8349	4043	·518 3508	6980	4710	6965	4026	36
25	9709	·475 1914	7669	7199	·541 0740	8543	·587 0876	8019	35
26	·454 3218	5481	·497 1297	·519 0891	4501	·564 2378	4788	·611 2014	34
27	6728	9048	4925	4584	8263	6213	8702	6011	33
28	·455 0238	·476 2616	8554	8278	·542 2027	·565 0050	·588 2616	·612 0008	32
29	3750	6185	·498 2185	·520 1974	5791	3888	6533	4007	31
30	7263	9755	5816	5671	9557	7728	·589 0450	8008	30
31	·456 0776	·477 3326	9449	9368	·543 3324	·566 1568	4369	·613 2010	29
32	4290	6899	·499 3082	·521 3067	7092	5410	8289	6013	28
33	7806	·478 0472	6717	6767	·544 0862	9254	·590 2211	·614 0018	27
34	·457 1322	4046	·500 0352	·522 0468	4632	·567 3098	6134	4024	26
35	4839	7621	3989	4170	8404	6944	·591 0058	8032	25
36	8357	·479 1197	7627	7874	·545 2177	·568 0791	3984	·615 2041	24
37	·458 1877	4774	·501 1266	·523 1578	5951	4639	7910	6052	23
38	5397	8352	4906	5284	9727	8488	·592 1839	·616 0064	22
39	8918	·480 1932	8547	8990	·546 3503	·569 2339	5768	4077	21
40	·459 2439	5512	·502 2189	·524 2698	7281	6191	9699	8092	20
41	5962	9093	5832	6407	·547 1060	·570 0045	·593 3632	·617 2108	19
42	9486	·481 2675	9476	·525 0117	4840	3899	7565	6126	18
43	·460 3011	6258	·503 3121	3829	8621	7755	·594 1501	·618 0145	17
44	6537	9842	6768	7541	·548 2404	·571 1612	5437	4166	16
45	·461 0063	·482 3427	·504 0415	·526 1255	6188	5471	9375	8188	15
46	3591	7014	4063	4969	9973	9331	·595 3314	·619 2211	14
47	7119	·483 0601	7713	8685	·549 3759	·572 3192	7255	6236	13
48	·462 0649	4189	·505 1363	·527 2402	7547	7054	·596 1196	·620 0263	12
49	4179	7778	5015	6120	·550 1335	·573 0918	5140	4291	11
50	7710	·484 1368	8668	9839	5125	4783	9084	8320	10
51	·463 1243	4959	·506 2322	·528 3560	8916	8649	·597 3030	·621 2351	9
52	4776	8552	5977	7281	·551 2708	·574 2516	6978	6383	8
53	8310	·485 2145	9633	·529 1004	6502	6385	·598 0926	·622 0417	7
54	·464 1845	5739	·507 3290	4727	·552 0297	·575 0255	4877	4452	6
55	5382	9334	6948	8452	4093	4126	8828	8488	5
56	8919	·486 2931	·508 0607	·530 2178	7890	7999	·599 2781	·623 2527	4
57	·465 2457	6528	4267	5906	·553 1688	·576 1873	6735	6566	3
58	5996	·487 0126	7929	9634	5488	5748	·600 0691	·624 0607	2
59	9536	3726	·509 1591	·531 3364	9288	9625	4648	4650	1
60	·466 3077	7326	5254	7094	·554 3091	·577 3503	8606	8694	0
′	65°	64°	63°	62°	61°	60°	59°	58°	′

NAT. COTAN.

′	32°	33°	34°	35°	36°	37°	38°	39°	′
0	·624 8694	·649 4076	·674 5085	·700 2075	726 5425	·753 5541	·781 2856	·809 7840	60
1	·625 2739	8212	9318	6411	9871	754 0102	7542	·810 2658	59
2	6786	·650 2350	·675 3553	·701 0749	·727 4318	4666	·782 2229	7478	58
3	·626 0834	6490	7790	5089	8767	9232	6919	·811 2300	57
4	4884	·651 0631	·676 2028	9430	728 3218	·755 3799	·783 1611	7124	56
5	8935	4774	6268	·702 3773	7671	8369	6305	·812 1951	55
6	·627 2988	8918	·677 0509	8118	·729 2125	·756 2941	·784 1002	6780	54
7	7042	·652 3064	4752	·703 2464	6582	7514	5700	·813 1611	53
8	·628 1098	7211	8997	6813	·730 1041	·757 2090	·785 0400	6444	52
9	5155	·653 1360	·678 3243	·704 1163	5501	6668	5103	·814 1280	51
10	9214	5511	7492	5515	9963	·758 1248	9808	6118	50
11	·629 3274	9663	·679 1741	9869	·731 4428	5829	·786 4515	·815 0958	49
12	7336	·654 3817	5993	·705 4224	8894	·759 0413	9224	5801	48
13	·630 1399	7972	·680 0246	8581	·732 3362	4999	·787 3935	·816 0646	47
14	5464	·655 2129	4501	·706 2940	7832	9587	8649	5493	46
15	9530	6287	8758	7301	·733 2303	·760 4177	·788 3364	·817 0343	45
16	·631 3598	·656 0447	·681 3016	·707 1664	6777	8769	8082	5195	44
17	7667	4609	7276	6028	·734 1253	·761 3363	·789 2802	·818 0049	43
18	·632 1738	8772	·682 1537	·708 0395	5730	7959	7524	4905	42
19	5810	·657 2937	5801	4763	·735 0210	·762 2557	·790 2248	9764	41
20	9883	7103	·683 0066	9133	4691	7157	6975	·819 4625	40
21	·633 3959	·658 1271	4333	·709 3504	9174	·763 1759	·791 1703	9488	39
22	8035	5441	8601	7878	·736 3660	6363	6434	·820 4354	38
23	·634 2113	9612	·684 2871	·710 2253	8147	·764 0969	·792 1167	9222	37
24	6193	·659 3785	7143	6630	·737 2636	5577	5902	·821 4093	36
25	.635 0274	7960	·685 1416	·711 1009	7127	·765 0188	·793 0640	8965	35
26	4357	·660 2136	5692	5390	·738 1620	4800	5379	·822 3840	34
27	8441	6313	9969	9772	6115	9414	·794 0121	8718	33
28	·636 2527	·661 0492	·686 4247	·712 4157	739 0611	·766 4031	4865	.823 3597	32
29	6614	4673	8528	8542	5110	8649	9611	8479	31
30	·637 0703	8856	·687 2810	·713 2931	9611	·767 3270	·795 4359	·824 3364	30
31	4793	·662 3040	7093	7320	·740 4115	7893	9110	8251	29
32	8885	7225	·688 1379	·714 1712	8618	·768 2517	·796 3862	·825 3140	28
33	·638 2978	·663 1413	5666	6106	·741 3124	7144	8617	8031	27
34	7073	5601	9955	·715 0501	7632	·769 1773	·797 3374	·826 2925	26
35	·639 1169	9792	·689 4246	4898	·742 2143	6404	8134	7821	25
36	5267	·664 3984	8538	9297	6655	·770 1037	·798 2895	·827 2719	24
37	9366	8178	·690 2832	·716 3698	·743 1170	5672	7659	7620	23
38	·640 3467	·665 2373	7128	8100	5686	·771 0309	·799 2425	·828 2523	22
39	7569	6570	·691 1425	·717 2505	·744 0204	4948	7193	7429	21
40	·641 1673	·666 0769	5725	6911	4724	9589	·800 1963	·829 2337	20
41	5779	4969	692 0026	·718 1319	9246	·772 4233	6736	7247	19
42	9886	9171	4328	5729	·745 3770	8878	·801 1511	·830 2160	18
43	·642 3994	·667 3374	8633	·719 0141	8296	·773 3526	6288	7075	17
44	8105	7580	.693 2939	4554	·746 2824	8176	·802 1067	·831 1992	16
45	·643 2216	·668 1786	7247	8970	7354	·774 2827	5849	6912	15
46	6329	5995	·694 1557	·720 3387	·747 1886	7481	·803 0632	·832 1834	14
47	.644 0444	·669 0205	5868	7806	6420	·775 2137	5418	6759	13
48	4560	4417	·695 0181	·721 2227	·748 0956	6795	·804 0206	·833 1686	12
49	8678	8630	4496	6650	5494	·776 1455	4997	6615	11
50	·645 2797	·670 2845	8813	·722 1075	·749 0033	6118	9790	·834 1547	10
51	6918	7061	.696 3131	5502	4575	·777 0782	·805 4584	6481	9
52	·646 1041	·671 1280	7451	9930	9119	5448	9382	·835 1418	8
53	5165	5500	·697 1773	·723 4361	·750 3665	·778 0117	·806 4181	6357	7
54	9290	9721	6097	8793	8212	4788	8983	·836 1298	6
55	·647 3417	·672 3944	·698 0422	·724 3227	·751 2762	9460	·807 3787	6242	5
56	7546	8169	4749	7663	7314	779 4135	8593	·837 1188	4
57	·648 1676	·673 2396	9078	·725 2101	·752 1867	8812	·808 3401	6136	3
58	5808	6624	·699 3409	6540	6423	·780 3492	8212	·838 1087	2
59	9941	·674 0854	7741	·726 0982	·753 0981	8173	·809 3025	6041	1
60	·649 4076	5085	·700 2075	5425	5541	·781 2856	7840	·839 0996	0
′	57°	56°	55°	54°	53°	52°	51°	50°	′

NAT. COTAN.

′	40°	41°	42°	43°	44°	45°	46°	47°	′
0	·839 0996	·869 2867	·900 4040	·932 5151	·965 6888	1·00 00000	1·03 55303	1·07 23687	60
1	5955	7976	9309	·933 0591	·966 2511	05819	61333	29943	59
2	·840 0915	·870 3087	·901 4580	6034	8137	11642	67367	36203	58
3	5878	8200	9854	·934 1479	·967 3767	17469	73404	42467	57
4	·841 0844	·871 3316	·902 5131	6928	9399	23298	79445	48734	56
5	5812	8435	·903 0411	·935 2380	·968 5035	29131	85489	55006	55
6	·842 0782	·872 3556	5693	7834	·969 0674	34968	91538	61282	54
7	5755	8680	·904 0979	·936 3292	6316	40807	97589	67561	53
8	·843 0730	·873 3806	6267	8753	·970 1962	46651	1·04 03645	73845	52
9	5708	8935	·905 1557	·937 4216	7610	52497	09704	80132	51
10	·844 0688	·874 4067	6851	9383	·971 3262	58348	15767	86423	50
11	5670	9201	·906 2147	·938 5153	8917	64201	21833	92718	49
12	·845 0655	·875 4338	7446	·939 0625	·972 4575	70058	27904	99018	48
13	5643	9478	·907 2748	6101	·973 0236	75918	33977	1·08 05321	47
14	·846 0633	·876 4620	8053	·940 1579	5901	81782	40055	11628	46
15	5625	9765	·908 3360	7061	·974 1569	87649	46136	17939	45
16	·847 0620	.877 4912	8671	941 2545	7240	93520	52221	24254	44
17	5617	.878 0062	·909 3984	8033	·975 2914	99394	58310	30573	43
18	·848 0617	5215	9300	·942 3523	8591	1·01 05272	64402	36896	42
19	5619	·879 0370	·910 4619	9017	·976 4272	11153	70498	43223	41
20	·849 0624	5528	9940	·943 4513	9956	17038	76598	49554	40
21	5631	·880 0688	·911 5265	·944 0013	·977 5643	22925	82702	55889	39
22	·850 0640	5852	·912 0592	5516	·978 1333	28817	88809	62228	38
23	5653	·881 1017	5922	·945 1021	7027	34712	94920	68571	37
24	·851 0667	6186	·913 1255	6530	·979 2724	40610	1·05 01034	74918	36
25	5684	·882 1357	6591	·946 2042	8424	46512	07153	81269	35
26	·852 0704	6531	·914 1929	7556	·980 4127	52418	13275	87624	34
27	5726	·883 1707	7270	·947 3074	9833	58326	19401	93984	33
28	·853 0750	6886	·915 2615	8595	·981 5543	64239	25531	1·09 00347	32
29	5777	·884 2068	7962	·948 4119	·982 1256	70155	31664	06714	31
30	·854 0807	7253	·916 3312	9646	6973	76074	37801	13085	30
31	5839	·885 2440	8665	·949 5176	·983 2692	81997	43942	19460	29
32	·855 0873	7030	·917 4020	·950 0709	8415	87923	50087	25840	28
33	5910	·886 2822	9379	6245	·984 4141	93853	56235	32223	27
34	·856 0950	8017	·918 4740	·951 1784	9871	99786	62388	38610	26
35	5992	·887 3215	·919 0104	7326	·985 5603	1·02 05723	68544	45002	25
36	·857 1037	8415	5471	·952 2871	·986 1339	11664	74704	51397	24
37	6084	·888 3619	·920 0841	8420	7079	17608	80367	57797	23
38	·858 1133	8825	6214	·953 3971	·987 2821	23555	87035	64201	22
39	6185	·889 4033	·921 1590	9526	8567	29506	93206	70609	21
40	·859 1240	9244	6969	·954 5083	·988 4316	35461	99381	77020	20
41	6297	·890 4458	·922 2350	·955 0644	·989 0069	41419	1·06 05560	83436	19
42	·860 1357	9675	7734	6208	5825	47381	11742	89857	18
43	6419	·891 4894	·923 3122	·956 1774	·990 1584	53346	17929	96281	17
44	·861 1484	·892 0116	8512	7344	7346	59315	24119	1·10 02709	16
45	6551	5341	·924 3905	957 2917	·991 3112	65287	30313	09141	15
46	·862 1621	·893 0569	9301	8494	8881	71263	36511	15578	14
47	6694	5799	·925 4700	·958 4073	·992 4654	77243	42713	22019	13
48	·863 1768	·894 1032	·926 0102	9655	·993 0429	83226	48918	28463	12
49	6846	6268	5506	·959 5241	6208	89212	55128	34912	11
50	·864 1926	·895 1506	·927 0914	·960 0829	·994 1991	95203	61341	41365	10
51	7009	6747	6324	6421	7777	1·03 01196	67558	47823	9
52	·865 2094	·896 1991	·928 1738	·961 2016	·995 3566	07194	73779	54284	8
53	7181	7238	7154	7614	9358	13195	80004	60750	7
54	·866 2272	·897 2487	·929 2573	·962 3215	·996 5154	19199	86233	67219	6
55	7366	7739	7996	8819	·997 0953	25208	92466	73693	5
56	·867 2460	·898 2994	·930 3421	·963 4427	6756	31220	98702	80171	4
57	7558	8251	8849	·964 0037	·998 2562	37235	1·07 04943	86653	3
58	·868 2659	·899 3512	·931 4280	5651	8371	43254	11187	93140	2
59	7762	8775	9714	·965 1268	.999 4184	49277	17435	99630	1
60	·869 2867	·900 4040	·932 5151	6888	1·000 0000	55303	23687	1·11 06125	0
′	49°	48°	47°	46°	45°	44°	43°	42°	′

NAT. COTAN.

′	48°	49°	50°	51°	52°	53°	54°	′
0	1·11 06125	1·15 03684	1·19 17536	1·23 48972	1·27 99416	1·32 70445	1·37 63819	60
1	12624	10445	24579	56319	1·28 07094	78483	72242	59
2	19127	17210	31626	63672	14776	86524	80672	58
3	25635	23979	38679	71030	22465	94571	89108	57
4	32146	30754	45736	78393	30160	1·33 02624	97551	56
5	38662	37532	52799	85762	37860	10684	1·38 06001	55
6	45182	44316	59866	93136	45566	18750	14458	54
7	51706	51104	66938	1·24 00515	53277	26822	22922	53
8	58235	57896	74015	07900	60995	34900	31392	52
9	64768	64693	81097	15290	68718	42984	39869	51
10	71305	71495	88184	22685	76447	51075	48353	50
11	77846	78301	95276	30086	84182	59172	56844	49
12	84391	85112	1·20 02373	37492	91922	67276	65342	48
13	90941	91927	09475	44903	99669	75386	73847	47
14	97495	98747	16581	52320	1·29 07421	83502	82358	46
15	1·12 04053	1·16 05571	23693	59742	15179	91624	90876	45
16	10616	12400	30810	67169	22943	99753	99401	44
17	17183	19264	37932	74602	30718	1·34 07888	1·39 07934	43
18	23754	26073	45058	82040	38488	16029	16473	42
19	30329	32916	52190	89484	46270	24177	25019	41
20	36909	39763	59327	96933	54057	32331	33571	40
21	43493	46615	66468	1·25 04388	61850	40492	42131	39
22	50081	53472	73615	11848	69649	48658	50698	38
23	56674	60334	80767	19313	77454	56832	59272	37
24	63271	67200	87924	26784	85265	65011	67852	36
25	69872	74071	95085	34260	93081	73198	76440	35
26	76478	80947	1·21 02252	41742	1·30 00904	81390	85034	34
27	83088	87827	09424	49229	08733	89589	93636	33
28	89702	94712	16601	56721	16567	97794	1·40 02245	32
29	96321	1·17 01601	23783	64219	24407	1·35 06006	10860	31
30	1·13 02944	08496	30970	71723	32254	14224	19483	30
31	09571	15395	38162	79232	40106	22449	28113	29
32	16203	22298	45359	86747	47964	30680	36749	28
33	22839	29207	52562	94267	55828	38918	45393	27
34	29479	36120	59769	1·26 01792	63699	47162	54044	26
35	36124	43038	66982	09323	71575	55413	62702	25
36	42773	49960	74199	16860	79457	63670	71367	24
37	49427	56888	81422	24402	87345	71934	80039	23
38	56085	63820	88650	31950	95239	80204	88718	22
39	62747	70756	95883	39503	1·31 03140	88481	97406	21
40	69414	77698	1·22 03121	47062	11046	96764	1·41 06098	20
41	76086	84644	10364	54626	18958	1·36 05054	14799	19
42	82761	91595	17613	62196	26876	13350	23506	18
43	89441	98551	24866	69772	34801	21653	32221	17
44	96126	1·18 05512	32125	77353	42731	29963	40943	16
45	1·14 02815	12477	39389	84940	50668	38279	49673	15
46	09508	19447	46658	92532	58610	46602	58403	14
47	16206	26422	53932	1·27 00130	66559	54931	67153	13
48	22908	33402	61211	07733	74513	63267	75904	12
49	29615	40387	68496	15342	82474	71610	84662	11
50	36326	47376	75786	22957	90441	79959	93427	10
51	43041	54370	83081	30578	98414	88315	1·42 02200	9
52	49762	61369	90381	38204	1·32 06393	96678	10979	8
53	56486	68373	97687	45835	14379	1·37 05047	19766	7
54	63215	75382	1·23 04997	53473	22370	13423	28561	6
55	69949	82395	12313	61116	30368	21806	37362	5
56	76687	89414	19634	68765	38371	30195	46171	4
57	83429	96437	26961	76419	46381	38591	54988	3
58	90176	1·19 03465	34292	84079	54397	40994	63811	2
59	96928	10498	41629	91745	62420	55403	72642	1
60	1·15 03684	17536	48972	99416	70448	63819	81480	0
′	41°	40°	39°	38°	37°	36°	35°	′

NAT. COTAN.

′	55°	56°	57°	58°	59°	60°	61°	′
0	1·42 81480	1·48 25610	1·53 98650	1·60 03345	1·66 42795	1·73 20508	1·80 40478	60
1	90326	34916	1·54 08460	13709	53766	32149	52860	59
2	99178	44231	18280	24082	64748	43803	65256	58
3	1·43 08039	53554	28108	34465	75741	55468	77664	57
4	16906	62884	37946	44858	86744	67144	90086	56
5	25781	72223	47792	55260	97758	78833	1·81 02521	55
6	34664	81570	57647	65672	1·67 08782	90533	14969	54
7	43554	90925	67510	76094	19818	1·74 02245	27430	53
8	52451	1·49 00288	77383	86525	30864	13969	39904	52
9	61356	09659	87264	96966	41921	25705	52391	51
10	70268	19039	97155	1·61 07417	52988	37453	64892	50
11	79187	28426	1·55 07054	17878	64067	49213	77405	49
12	88114	37822	16963	28349	75156	60984	89932	48
13	97049	47225	26880	38829	86256	72768	1·82 02473	47
14	1·44 05931	56637	36806	49320	97367	84564	15026	46
15	14940	66058	46741	59820	1·68 08489	96371	27593	45
16	23897	75480	56685	70330	19621	1·75 08191	40173	44
17	32862	84923	66639	80850	30765	20023	52767	43
18	41834	94367	76601	91380	41919	31866	65374	42
19	50814	1·50 03821	86572	1·62 01920	53085	43722	77994	41
20	59801	13282	96552	12469	64261	55590	90628	40
21	68796	22751	1·56 06542	23029	75449	67470	1·83 03275	39
22	77798	32229	16540	33599	86647	79362	15936	38
23	86808	41716	26548	44178	97856	91267	28610	37
24	95825	51210	36564	54768	1·69 09077	1·76 03183	41297	36
25	1·45 04850	60713	46590	65368	20308	15112	53999	35
26	13883	70224	56625	75977	31550	27053	66713	34
27	22923	79743	66669	86597	42804	39007	79442	33
28	31971	89271	76722	97227	54069	50972	92184	32
29	41027	98807	86784	1·63 07867	65344	62950	1·84 04940	31
30	50090	1·51 08352	96856	18517	76631	74940	17709	30
31	59161	17905	1·57 06936	29177	87929	86943	30492	29
32	68240	27466	17026	39847	99238	98958	43289	28
33	77326	37036	27126	50528	1·70 10559	1·77 10985	56099	27
34	86420	46614	37234	61218	21890	23024	68923	26
35	95522	56201	47352	71919	33233	35076	81761	25
36	1·46 04632	65796	57479	82630	44587	47141	94613	24
37	13749	75400	67615	93351	55953	59218	1·85 07479	23
38	22874	85012	77760	1·64 04082	67329	71307	20358	22
39	32007	94632	87915	14824	78717	83409	33252	21
40	41147	1·52 04261	98079	25576	90116	95524	46159	20
41	50296	13899	1·58 08253	36338	1·71 01527	1·78 07651	59080	19
42	59452	23545	18436	47111	12949	19790	72015	18
43	68616	33200	28628	57893	24382	31943	84965	17
44	77788	42863	38830	68687	35827	44107	97928	16
45	86967	52535	49041	79490	47283	56285	1·86 10905	15
46	96155	62215	59261	90304	58751	68475	23896	14
47	1·47 05350	71904	69491	1·65 01128	70230	80678	36902	13
48	14553	81602	79731	11963	81720	92893	49921	12
49	23764	91308	89979	22808	93222	1·79 05121	62955	11
50	32983	1·53 01023	1·59 00238	33663	1·72 04736	17362	76003	10
51	42210	10746	10505	44529	16261	29616	89065	9
52	51445	20479	20783	55405	27797	41883	1·87 02141	8
53	60688	30219	31070	66292	39346	54162	15231	7
54	69938	39969	41366	77189	50905	66454	28336	6
55	79197	49727	51672	88097	62477	78759	41455	5
56	88463	59494	61987	99016	74060	91077	54588	4
57	97738	69270	72312	1·66 09945	85654	1·80 03408	67736	3
58	1·48 07021	79054	82647	20884	97260	15751	80898	2
59	16311	88848	92991	31834	1·73 08878	28108	94074	1
60	25610	98650	1·60 03345	42795	20508	40478	1·88 07265	0
′	34°	33°	32°	31°	30°	29°	28°	′

NAT. COTAN

′	62°	63°	64°	65°	66°	67°	68°	′
0	1·88 07265	1·96 26105	2·05 03038	2·14 45069	2·24 60368	2·35 58524	2·47 50869	60
1	20470	40227	18185	61366	77962	77590	71612	59
2	33690	54364	33349	77683	95580	96683	92386	58
3	46924	68518	48531	94021	2·25 13221	2·36 15801	2·48 13190	57
4	60172	82688	63732	2·15 10378	30885	34946	34023	56
5	73436	96874	78950	26757	48572	54118	54887	55
6	86713	1·97 11077	94187	43156	66283	73316	75781	54
7	1·89 00006	25296	2·06 09442	59575	84016	92540	96706	53
8	13313	39531	24716	76015	2·26 01773	2·37 11791	2·49 17660	52
9	26635	53782	40008	92476	19554	31068	38645	51
10	39971	68050	55318	2·16 08958	37357	50372	59661	50
11	53322	82334	70646	25460	55184	69703	80707	49
12	66688	96635	85994	41983	73035	89060	2·50 01784	48
13	80068	1·98 10952	2·07 01359	58527	90909	2 38 08444	22891	47
14	93464	25286	16743	75091	2·27 08807	27855	44029	46
15	1·90 06874	39636	32146	91677	26729	47293	65198	45
16	20299	54003	47567	2·17 08283	44674	66758	86398	44
17	33738	68387	63007	24911	62643	86250	2·51 07629	43
18	47193	82787	78465	41559	80636	2·39 05769	28890	42
19	60663	97204	93942	58229	98653	25316	50183	41
20	74147	1·99 11637	2·08 09438	74920	2·28 16693	44889	71507	40
21	87647	26087	24953	91631	34758	64490	92863	39
22	1·91 01162	40554	40487	2·18 08364	52846	84118	2·52 14249	38
23	14691	55038	56039	25119	70959	2·40 03774	35667	37
24	28236	69539	71610	41894	89096	23457	57117	36
25	41795	84056	87200	58091	2·29 07257	43168	78598	35
26	55370	98590	2·09 02809	75510	25442	62906	2·53 00111	34
27	68960	2·00 13142	18437	92349	43651	82672	21655	33
28	82565	27710	34085	2·19 09210	61885	2·41 02465	43231	32
29	96186	42295	49751	26093	80143	22286	64839	31
30	1·92 09821	56897	65436	42997	98425	42136	86479	30
31	23472	71516	81140	59923	2·30 16732	62013	2·54 08151	29
32	37138	86153	96864	76871	35064	81918	29855	28
33	50819	2·01 00806	2·10 12607	93840	53420	2·42 01851	51591	27
34	64516	15477	28369	2·20 10831	71801	21812	73359	26
35	78228	30164	44150	27843	90206	41801	95160	25
36	91956	44869	59951	44878	2·31 08637	61819	2·55 16992	24
37	1·93 05699	59592	75771	61934	27092	81864	38858	23
38	19457	74331	91611	79012	45571	2·43 01938	60756	22
39	33231	89088	2·11 07470	96112	64076	22041	82686	21
40	47020	2·02 03862	23348	2·21 13234	82606	42172	2·56 04649	20
41	60825	18654	39246	30379	2·32 01160	62331	26645	19
42	74645	33462	55164	47545	19740	82519	48674	18
43	88481	48289	71101	64733	38345	2·44 02736	70735	17
44	1·94 02333	63133	87057	81944	56975	22982	92830	16
45	16200	77994	2·12 03034	99177	75630	43256	2·57 14957	15
46	30083	92873	19030	2·22 16432	94311	63559	37118	14
47	43981	2·03 07769	35046	33709	2·33 13017	83891	59312	13
48	57896	22683	51082	51009	31748	2 45 04252	81539	12
49	71826	37615	67137	68331	50505	24642	2·58 03800	11
50	85772	52565	83213	85676	69287	45061	26094	10
51	99733	67532	99308	2·23 03043	88095	65510	48421	9
52	1·95 13711	82517	2·13 15423	20433	2·34 06928	85987	70782	8
53	27704	97519	31559	37845	25787	2.46 06494	93177	7
54	41713	2·04 12540	47714	55280	44672	27030	2·59 15606	6
55	55739	27578	63890	72738	63582	47596	38068	5
56	69780	42634	80085	90218	82519	68191	60564	4
57	83837	57708	96301	2·24 07721	2·35 01481	88816	83095	3
58	97910	72800	2·14 12537	25247	20469	2·47 09470	2·60 05659	2
59	1·96 12000	87910	28793	42796	39483	30155	28258	1
60	26105	2·05 03038	45069	60368	58524	50869	50891	0
′	27°	26°	25°	24°	23°	22°	21°	′

NAT. COTAN,

′	69°	70°	71°	72°	73°	74°	75°	′
0	2·60 50891	2·74 74774	2·90 42109	3·07 76835	3·27 08526	3·48 74144	3·73 20508	60
1	73558	99651	69570	3·08 07325	42588	3·49 12470	63980	59
2	96259	2·75 24588	97089	37869	76715	50874	3·74 07546	58
3	2·61 18995	49554	2·91 24649	68468	3·28 10907	89356	51207	57
4	41766	74561	52250	99122	45164	3·50 27916	94963	56
5	64571	99608	79909	3·09 29831	79487	66555	3·75 38815	55
6	87411	2·76 24695	2·92 07610	60596	3·29 13876	3·51 05273	82763	54
7	2·62 10286	49822	35358	91416	48330	44070	3·76 26807	53
8	33196	74990	63152	3·10 22291	82851	82946	70947	52
9	56141	2·77 00199	90995	53223	3·30 17438	3·52 21902	3·77 15185	51
10	79121	25448	2·93 18885	84210	52091	60938	59519	50
11	2·63 02136	50738	46822	3·11 15254	86811	3·53 00054	3·78 03951	49
12	25186	76069	74807	46353	3·31 21598	39251	48481	48
13	48271	2·78 01440	2·94 02840	77509	56452	78528	93109	47
14	71392	26853	30921	3·12 08722	91373	3·54 17886	3·79 37835	46
15	94549	52307	59050	39991	3·32 26362	57325	82661	45
16	2·64 17741	77802	87227	71317	61419	96846	3·80 27585	44
17	40969	2·79 03339	2·95 15453	3·13 02701	96543	3·55 36449	72609	43
18	64232	28917	43727	34141	3·33 31736	76133	3·81 17733	42
19	87531	54537	72050	65639	66997	3·56 15900	62957	41
20	2·65 10867	80198	2·96 00422	97194	3·34 02326	55749	3·82 08281	40
21	34238	2·80 05901	28842	3·14 28807	37724	95681	53707	39
22	57645	31646	57312	60478	73191	3·57 35696	99233	38
23	81089	57433	85831	92207	3·35 08728	75794	3·83 44861	37
24	2·66 04569	83263	2·97 14399	3·15 23994	44333	3·58 15975	90591	36
25	28085	2·81 09134	43016	55840	80008	56241	3·84 36424	35
26	51638	35048	71683	87744	3·36 15753	96590	82358	34
27	75227	61004	2·98 00400	3·16 19706	51568	3·59 37024	3·85 28396	33
28	98853	87003	29167	51728	87453	77543	74537	32
29	2·67 22516	2·82 13045	57983	83808	3·37 23408	3·60 18146	3·86 20782	31
30	46215	39129	86850	3·17 15948	59434	58835	67131	30
31	69951	65256	2·99 15766	48147	95531	99609	3·87 13584	29
32	93725	91426	44734	80406	3·38 31699	3·61 40469	60142	28
33	2·68 17535	2·83 17639	73751	3·18 12724	67938	81415	3·88 06805	27
34	41383	43896	3·00 02820	45102	3·39 04249	3·62 22447	53574	26
35	65267	70196	31939	77540	40631	63566	3·89 00448	25
36	89190	96539	61109	3·19 10039	77085	3·63 04771	47429	24
37	2·69 13149	2·84 22926	90330	42598	3·40 13612	46064	94516	23
38	37147	49356	3·01 19603	75217	50210	87444	3·90 41710	22
39	61181	75831	48926	3·20 07897	86882	3·64 28911	89011	21
40	85254	2·85 02349	78301	40638	3·41 23626	70467	3·91 36420	20
41	2·70 09364	28911	3·02 07728	73440	60443	3·65 12111	83937	19
42	33513	55517	37207	3·21 06304	97333	53844	3·92 31563	18
43	57699	82168	66737	39228	3·42 34297	95665	79297	17
44	81923	2·86 08863	96320	72215	71334	3·66 37575	3·93 27141	16
45	2·71 06186	35602	3·03 25954	3·22 05263	3·43 08446	79575	75094	15
46	30487	62386	55641	38373	45631	3·67 21665	3·94 23157	14
47	54826	89215	85381	71546	82891	63845	71331	13
48	79204	2·87 16088	3·04 15173	3·23 04780	3·44 20226	3·68 06115	3·95 19615	12
49	2·72 03620	43007	45018	38078	57635	48475	68011	11
50	28076	69970	74915	71438	95120	90927	3·96 16518	10
51	52569	96979	3·05 04866	3·24 04860	3·45 32679	3·69 33469	65137	9
52	77102	2·88 24033	34870	38346	70315	76104	3·97 13868	8
53	2·73 01674	51132	64928	71895	3·46 08026	3·70 18830	62712	7
54	26284	78277	95038	3·25 05508	45813	61648	3·98 11669	6
55	50934	2·89 05467	3·06 25203	39184	83676	3·71 04558	60739	5
56	75623	32704	55421	72924	3·47 21616	47561	3·99 09924	4
57	2·74 00352	59986	85694	3·26 06728	59632	90658	59223	3
58	25120	87314	3·07 16020	40596	97726	3·72 33847	4·00 08636	2
59	49927	2·90 14688	46400	74529	3·48 35896	77131	58165	1
60	74774	42109	76835	3·27 08526	74144	3·73 20508	4·01 07809	0
′	20°	19°	18°	17°	16°	15°	14°	′

NAT. COTAN.

′	76°	77°	78°	79°	80°	81°	82°	′
0	4·01 07809	4·33 14759	4·70 46301	5·1 445540	5·6 712818	6·3 137515	7·1 153697	60
1	57570	72316	4·71 13686	525557	809446	256601	304190	59
2	4·02 07446	4·34 30018	81250	605813	906394	376126	455308	58
3	57440	87866	4·72 49012	686311	5·7 003663	496092	607056	57
4	4·03 07550	4·35 45861	4·73 16354	767051	101256	616502	759437	56
5	57779	4·36 04003	85083	848035	199173	737359	912456	55
6	4·04 08125	62293	4·74 53401	929264	297416	858665	7·2 066116	54
7	58590	4·37 20731	4·75 21907	5·2 010738	395988	980422	220422	53
8	4·05 09174	79317	90603	092459	494889	6·4 102633	375378	52
9	59877	4·38 38054	4·76 59490	174428	594122	225301	530987	51
10	4·06 10700	93940	4·77 28568	256647	693688	348428	687255	50
11	61643	4·39 55977	97837	339116	793588	472017	844184	49
12	4·07 12707	4·40 15164	4·78 67300	421836	893825	596070	7·3 001780	48
13	63892	74504	4·79 36957	504809	994400	720591	160047	47
14	4·08 15199	4·41 33996	4·80 06808	588035	5·8 095315	845581	318989	46
15	66627	93641	76854	671517	196572	971043	478610	45
16	4·09 18178	4·42 53439	4·81 47096	755255	298172	6·5 096981	638916	44
17	69852	4·43 13392	4·82 17536	839251	400117	223396	799909	43
18	4·10 21649	73500	88174	923505	502410	350293	961595	42
19	73569	4·44 33762	4·83 59010	5·3 008018	605051	477672	7·4 123978	41
20	4·11 25614	94181	4·84 30045	092793	708042	605538	287064	40
21	77784	4·45 54756	4·85 01282	177830	811386	733892	450855	39
22	4·12 30079	4·46 15489	72719	263131	915084	862739	615357	38
23	82499	76379	4·86 44359	348696	5·9 019138	992080	780576	37
24	4·13 35046	4·47 37428	4·87 16201	434527	123550	6·6 121919	946514	36
25	87719	98636	88248	520626	228322	252258	7·5 113178	35
26	4·14 40519	4·48 60004	4·88 60499	606993	333455	383100	280571	34
27	93446	4·49 21532	4·89 32956	693630	438952	514449	448699	33
28	4·15 46501	83221	4·90 05620	780538	544815	646307	617567	32
29	99685	4·50 45072	78491	867718	651045	778677	787179	31
30	4·16 52998	4·51 07085	4·91 51570	955172	757644	911562	957541	30
31	4·17 06440	69261	4·92 24859	5·4 042901	864614	6·7 044966	7·6 128657	29
32	60011	4·52 31601	98358	130906	971957	178891	300533	28
33	4·18 13713	94105	4·93 72068	219188	6·0 079676	313341	473174	27
34	67546	4·53 56773	4·94 45990	307750	187772	448318	646584	26
35	4·19 21510	4·54 19608	4·95 20125	396592	296247	583826	820769	25
36	75606	82608	94474	485715	405103	719867	995735	24
37	4·20 29835	4·55 45776	4·96 69037	575121	514343	856446	7·7 171486	23
38	84196	4·56 09111	4·97 43817	664812	623967	993565	348028	22
39	4·21 38690	72615	4·98 18813	754788	733979	6·8 131227	525866	21
40	93318	4·57 36287	94027	845052	844381	269437	703506	20
41	4·22 48080	4·58 00129	4·99 69459	935604	955174	408196	882453	19
42	4·23 02977	64141	5·00 45111	5·5 026446	6·1 066360	547508	7·8 062212	18
43	58009	4·59 28325	5·01 20984	117579	177943	687378	242790	17
44	4·24 13177	92680	97078	209005	289923	827807	424191	16
45	68482	4·60 57207	5·02 73395	300724	402303	968799	606423	15
46	4·25 23923	4·61 21908	5·03 49935	392740	515085	6·9 110359	789489	14
47	79501	86783	5·04 26700	485052	628272	252489	973396	13
48	4·26 35218	4·62 51832	5·05 03690	577663	741865	395192	7·9 158151	12
49	91072	4·63 17056	80907	670574	855867	538473	343758	11
50	4·27 47066	82457	5·06 58352	763786	970279	682335	530224	10
51	4·28 03199	4·64 48034	5·07 36025	857302	6·2 085106	826781	717555	9
52	59472	4·65 13788	5·08 13928	951121	200347	971806	905756	8
53	4·29 15885	79721	92061	5·6 045247	316007	7·0 117441	8·0 094835	7
54	72440	4·66 45832	5·09 70426	139680	432086	263662	284796	6
55	4·30 29136	4·67 12124	5·10 49024	234421	548588	410482	475647	5
56	85974	78595	5·11 27855	329474	665515	557906	667394	4
57	4·31 42955	4·68 45248	5·12 06921	424838	782868	705934	860042	3
58	4·32 00079	4·69 12083	86224	520516	900651	854573	8·1 053699	2
59	57347	79100	5·13 65763	616509	6·3 018866	7·1 003826	248071	1
60	4·33 14759	4·70 46301	5·14 45540	712818	137515	153697	443464	0
′	13°	12°	11°	10°	9°	8°	7°	′

NAT. COTAN.

′	83°	84°	85°	86°	87°	88°	89°	′
0	8·1 443464	9·5 143645	11.430052	14·300666	19·081137	28·636253	57·289962	60
1	639786	410613	468474	360696	187930	877089	58·261174	59
2	837041	679068	507154	421230	295922	29·122006	59·265872	58
3	8·2 035239	949022	546093	482273	405133	371106	60·305820	57
4	234384	9·6 220486	585294	543833	515584	624499	61·382905	56
5	434485	493475	624761	605916	627296	882299	62·499154	55
6	635547	768000	664495	668529	740291	30·144619	63·656741	54
7	837579	9·7 044075	704500	731679	854591	411580	64·858008	53
8	8·3 040586	321713	744779	795372	970219	683307	66·105473	52
9	244577	600927	785333	859616	20·087199	959928	67·401854	51
10	449558	881732	826167	924417	205553	31·241577	68·750087	50
11	655536	9·8 164140	867282	989784	325308	528392	70·153346	49
12	862519	448166	908682	15·055723	446486	820516	71·615070	48
13	8·4 070515	733823	950370	122242	569115	32·118099	73·138901	47
14	279531	9·9 021125	992349	189349	693220	421295	74·729165	46
15	489573	310088	12.034622	257052	818828	730265	76·390009	45
16	700651	600724	077192	325358	945966	33·045173	78·126342	44
17	912772	893050	120062	394276	21·074664	366194	79·943430	43
18	8·5 125943	10·018708	163236	463814	204949	693509	81·847041	42
19	340172	048283	206716	533981	336851	34·027303	83·843507	41
20	555468	078031	250505	604784	470401	367771	85·939791	40
21	771838	107954	294609	676233	605630	715115	88·143572	39
22	989290	138054	339028	748337	742569	35·069546	90·463336	38
23	8·6 207833	168332	383768	821105	881251	431282	92·908487	37
24	427475	198789	428831	894545	22·021710	800553	95·489475	36
25	648223	229428	474221	968667	163980	36·177596	98·217943	35
26	870088	260249	519942	16·043482	308097	562659	101·10690	34
27	8·7 093077	291255	565997	118998	454096	956001	104·17094	33
28	317198	322447	612390	195225	602015	37·357892	107·42648	32
29	542461	353827	659125	272174	751892	768613	110·89205	31
30	768874	385397	706205	349855	903766	38·188459	114·58865	30
31	996446	417158	753634	428279	23·057677	617738	118·54018	29
32	8·8 225186	449112	801417	507456	213666	39·056771	122·77396	28
33	455103	481261	849557	587396	371777	505895	127·32134	27
34	686206	513607	898058	668112	532052	965460	132·21851	26
35	918505	546151	946924	749614	694537	40·435837	137·50745	25
36	8·9 152009	578895	996160	831915	859277	917412	143·23712	24
37	386726	611841	13·045769	915025	24·026320	41·410588	149·46502	23
38	622668	644992	095757	998957	195714	915790	156·25908	22
39	859843	678348	146127	17·083724	367509	42·433464	163·70019	21
40	9·0 098261	711913	196883	169337	541758	964077	171·88540	20
41	337933	745687	248031	255809	718512	43·508122	180·93220	19
42	578867	779673	299574	343155	897826	44·066113	190·98419	18
43	821074	813872	351518	431385	25·079757	638596	202·21875	17
44	9·1 064564	848288	403867	520516	264361	45·226141	214·85762	16
45	309348	882921	456625	610559	451700	829351	229·18166	15
46	555436	917775	509799	701529	641832	46·448862	245·55198	14
47	802838	952850	563391	793442	834823	47·085343	264·44080	13
48	9·2 051564	988150	617409	886310	26·030736	739501	286·47773	12
49	301627	11·023676	671856	980150	229638	48·412084	312·52137	11
50	553035	059431	726738	18·074977	431600	49·102881	343·77371	10
51	805802	095416	782060	170807	636690	815726	381·97099	9
52	9·3 059936	131635	837827	267654	844984	50·548506	429·71757	8
53	315450	168089	894045	365537	27·056557	51·303157	491·10600	7
54	572355	204780	950719	464471	271486	52·080673	572·95721	6
55	830663	241712	14·007856	564473	489853	882109	687·54887	5
56	9·4 090384	278885	065459	665562	711740	53·708587	859·43630	4
57	351531	316304	123536	767754	937233	54·561300	1145·9153	3
58	614116	353970	182092	871068	28·166422	55·441517	1718·8732	2
59	878149	391885	241134	975523	399397	56·350590	3437·7467	1
60	9.5 143645	430052	300666	19·081137	636253	57·289962	Infinite.	0
′	6°	5°	4°	3°	2°	1°	0°	′

NAT. COTAN.

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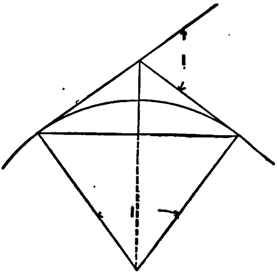
TABLE XVI.

CHORDS, MIDDLE ORDINATES, EXTERNAL SECANTS, AND APEX DISTANCES OF A ONE-DEGREE CURVE.



The angles of the table are the intersection angles, I, equal to the total central angle included between the tangent points.

To find the corresponding function for any other curve, divide the tabular number by the degree of curvature.

The unit chord is assumed to be one hundred feet long.

By using radius of 5,730 feet, the chord column of the table can be made serviceable for plotting.

To use the table for curves having chords of 20 metres each, divide the several tabular functions, that is to say, the Chord, Ordinate, Ex-sec, and Apex Distance, by 5 times the proposed metric degree of curve, for the proper values of said functions in metric measure. Thus, for a 2° metric curve, chords 20 metres each, the divisor would be $2 \times 5 = 10$; for a 2° 30′ curve, 12.5, and so on; taking care to reduce minutes to decimals of a degree before making the multiplication for a divisor in each case.

Also, if the length in metres of any proposed Chord, Ordinate, Ex-sec or A. D. for a given angle be known, the tabular function corresponding to that angle divided by 5 times the known chord, ordinate, etc., will ascertain the degree of curvature for chords of 20 metres each, using the foregoing precaution as to decimals.

Example 1.—4° curve, intersection angle 48°, 20-metre chords, ∴ apex dist. $= 2551.1 \div 5 \times 4 = 127.55$ metres.

Example 2.—Apex distance 200 metres, angle 58° 20′, ∴ degree of metric curve $= 3198 \div 200 \times 5 = 3\frac{2}{10}$ degrees $= 3° 12′$, chords being 20 metres each.

	0°.					1°.					
Min.	Chord.	Mid. Ord.	Ex. Sec.	A. D.	Min.	Min.	Chord.	Mid. Ord.	Ex. Sec.	A. D.	Min.
0	0.00	0.000	0.000	0.00	0	0	100.00	0.218	0.218	50.00	0
2	3.33	0.000	0.000	1.67	2	2	103.33	0.233	0.233	51.67	2
4	6.67	0.001	0.001	3.33	4	4	106.66	0.248	0.248	53.33	4
6	10.00	0.002	0.002	5.00	6	6	110.00	0.264	0.264	55.00	6
8	13.33	0.004	0.004	6.67	8	8	113.33	0.280	0.280	56.67	8
10	16.67	0.006	0.006	8.33	10	10	116.66	0.297	0.297	58.33	10
12	20.00	0.009	0.009	10.00	12	12	120.00	0.314	0.314	60.00	12
14	23.33	0.012	0.012	11.67	14	14	123.33	0.332	0.332	61.67	14
16	26.67	0.015	0.015	13.33	16	16	126.66	0.350	0.350	63.33	16
18	30.00	0.019	0.019	15.00	18	18	130.00	0.368	0.368	65.00	18
20	33.33	0.024	0.024	16.67	20	20	133.33	0.388	0.388	66.67	20
22	36.67	0.029	0.029	18.33	22	22	136.66	0.407	0.407	68.33	22
24	40.00	0.035	0.035	20.00	24	24	140.00	0.427	0.427	70.00	24
26	43.33	0.041	0.041	21.67	26	26	143.33	0.448	0.448	71.67	26
28	46.67	0.048	0.048	23.33	28	28	146.66	0.469	0.469	73.33	28
30	50.00	0.054	0.054	25.00	30	30	150.00	0.491	0.491	75.00	30
32	53.33	0.062	0.062	26.67	32	32	153.33	0.513	0.513	76.67	32
34	56.67	0.070	0.070	28.33	34	34	156.66	0.536	0.536	78.33	34
36	60.00	0.079	0.079	30.00	36	36	160.00	0.559	0.559	80.00	36
38	63.33	0.088	0.088	31.67	38	38	163.33	0.582	0.582	81.67	38
40	66.67	0.097	0.097	33.33	40	40	166.66	0.606	0.606	83.33	40
42	70.00	0.107	0.107	35.00	42	42	170.00	0.630	0.630	85.00	42
44	73.33	0.117	0.117	36.67	44	44	173.33	0.655	0.655	86.67	44
46	76.67	0.128	0.128	38.33	46	46	176.66	0.681	0.681	88.33	46
48	80.00	0.140	0.140	40.00	48	48	180.00	0.706	0.706	90.00	48
50	83.33	0.151	0.151	41.67	50	50	183.33	0.733	0.733	91.67	50
52	86.67	0.164	0.164	43.33	52	52	186.66	0.760	0.760	93.33	52
54	90.00	0.176	0.176	45.00	54	54	190.00	0.788	0.788	95.00	54
56	93.33	0.190	0.190	46.67	56	56	193.33	0.815	0.815	96.67	56
58	96.67	0.204	0.204	48.33	58	58	196.66	0.844	0.844	98.33	58
60	100.00	0.218	0.218	50.00	60	60	199.98	0.873	0.873	100.00	60

2°.						3°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	199.98	0.873	0.873	100.00	0	0	299.96	1.964	1.964	150.07	0
2	203.31	0.902	0.902	101.67	2	2	303.29	2.008	2.009	151.74	2
4	206.64	0.932	0.932	103.34	4	4	306.62	2.053	2.054	153.41	4
6	209.97	0.962	0.962	105.01	6	6	309.95	2.098	2.099	155.08	6
8	213.31	0.993	0.993	106.68	8	8	313.29	2.143	2.144	156.75	8
10	216.64	1.024	1.024	108.35	10	10	316.62	2.188	2.189	158.42	10
12	219.97	1.056	1.056	110.02	12	12	319.95	2.235	2.236	160.09	12
14	223.30	1.088	1.088	111.69	14	14	323.28	2.282	2.283	161.76	14
16	226.64	1.121	1.121	113.36	16	16	326.62	2.329	2.330	163.43	16
18	229.97	1.154	1.154	115.02	18	18	329.95	2.376	2.377	165.09	18
20	233.30	1.188	1.188	116.69	20	20	333.28	2.424	2.425	166.76	20
22	236.63	1.222	1.222	118.36	22	22	336.61	2.473	2.474	168.43	22
24	239.97	1.256	1.256	120.03	24	24	339.95	2.523	2.523	170.10	24
26	243.30	1.292	1.292	121.70	26	26	343.28	2.572	2.573	171.77	26
28	246.63	1.328	1.328	123.37	28	28	346.61	2.622	2.623	173.44	28
30	249.96	1.364	1.364	125.03	30	30	349.94	2.672	2.673	175.10	30
32	253.29	1.399	1.399	126.70	32	32	353.27	2.724	2.725	176.72	32
34	256.62	1.437	1.437	128.37	34	34	356.60	2.776	2.777	178.39	34
36	259.96	1.475	1.475	130.04	36	36	359.94	2.828	2.829	180.06	36
38	263.29	1.513	1.513	131.71	38	38	363.27	2.880	2.881	181.73	38
40	266.62	1.552	1.552	133.38	40	40	366.60	2.933	2.934	183.40	40
42	269.96	1.592	1.592	135.05	42	42	369.94	2.987	2.988	185.07	42
44	273.29	1.632	1.632	136.72	44	44	373.27	3.042	3.043	186.74	44
46	276.62	1.672	1.672	138.38	46	46	376.60	3.096	3.097	188.40	46
48	279.96	1.712	1.712	140.05	48	48	379.94	3.151	3.152	190.07	48
50	283.29	1.752	1.752	141.72	50	50	383.27	3.206	3.207	191.74	50
52	286.62	1.794	1.794	143.39	52	52	386.60	3.263	3.264	193.41	52
54	289.96	1.836	1.836	145.06	54	54	389.94	3.320	3.321	195.08	54
56	293.29	1.878	1.878	146.73	56	56	393.27	3.377	3.378	196.75	56
58	296.62	1.921	1.921	148.40	58	58	396.60	3.434	3.435	198.42	58
60	299.96	1.964	1.964	150.07	60	60	399.94	3.491	3.492	200.09	60

	4°.					5°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN
0	399.94	3.491	3.492	200.09	0	0	499.88	5.454	5.459	250.17	0
2	403.27	3.550	3.551	201.76	2	2	503.21	5.527	5.533	251.84	2
4	406.60	3.609	3.610	203.43	4	4	506.54	5.601	5.607	253.51	4
6	409.93	3.668	3.670	205.10	6	6	509.87	5.675	5.681	255.18	6
8	413.26	3.727	3.730	206.77	8	8	513.20	5.749	5.755	256.85	8
10	416.59	3.787	3.790	208.44	10	10	516.53	5.823	5.829	258.52	10
12	419.92	3.848	3.851	210.11	12	12	519.86	5.899	5.905	260.20	12
14	423.26	3.910	3.913	211.77	14	14	523.19	5.975	5.981	261.86	14
16	426.59	3.972	3.975	213.45	16	16	526.52	6.052	6.058	263.54	16
18	429.92	4.034	4.037	215.11	18	18	529.85	6.129	6.135	265.20	18
20	433.25	4.096	4.099	216.78	20	20	533.18	6.206	6.212	266.87	20
22	436.58	4.160	4.163	218.45	22	22	536.51	6.284	6.290	268.54	22
24	439.91	4.224	4.227	220.12	24	24	539.84	6.362	6.369	270.21	24
26	443.24	4.288	4.291	221.79	26	26	543.17	6.441	6.448	271.88	26
28	446.58	4.353	4.356	223.46	28	28	546.50	6.520	6.527	273.54	28
30	449.91	4.418	4.421	225.13	30	30	549.83	6.599	6.606	275.21	30
32	453.24	4.484	4.487	226.80	32	32	553.17	6.680	6.687	276.88	32
34	456.57	4.550	4.554	228.47	34	34	556.50	6.761	6.768	278.55	34
36	459.90	4.617	4.621	230.14	36	36	559.83	6.842	6.849	280.23	36
38	463.23	4.684	4.688	231.81	38	38	563.16	6.923	6.931	281.90	38
40	466.56	4.751	4.755	233.48	40	40	566.49	7.005	7.013	283.57	40
42	469.89	4.820	4.824	235.15	42	42	569.82	7.088	7.096	285.24	42
44	473.23	4.889	4.893	236.82	44	44	573.15	7.171	7.180	286.91	44
46	476.56	4.958	4.962	238.48	46	46	576.48	7.255	7.264	288.59	46
48	479.89	5.027	5.031	240.15	48	48	579.81	7.339	7.348	290.26	48
50	483.22	5.096	5.100	241.82	50	50	583.14	7.423	7.432	291.93	50
52	486.55	5.167	5.171	243.49	52	52	586.47	7.508	7.517	293.60	52
54	489.88	5.238	5.243	245.16	54	54	589.80	7.593	7.603	295.27	54
56	493.21	5.310	5.315	246.83	56	56	593.13	7.678	7.689	296.95	56
58	496.54	5.382	5.387	248.50	58	58	596.46	7.764	7.775	298.62	58
60	499.88	5.454	5.459	250.17	60	60	599.80	7.850	7.861	300.30	60

6°.						7°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	599.80	7.850	7.861	300.30	0	0	699.60	10.69	10.71	350.44	0
2	603.13	7.940	7.951	301.97	2	2	702.93	10.79	10.81	352.11	2
4	606.46	8.030	8.041	303.64	4	4	706.26	10.90	10.92	353.79	4
6	609.78	8.120	8.131	305.31	6	6	709.58	11.00	11.02	355.46	6
8	613.11	8.210	8.221	306.98	8	8	712.91	11.11	11.13	357.13	8
10	616.44	8.300	8.311	308.65	10	10	716.24	11.21	11.23	358.81	10
12	619.76	8.390	8.401	310.32	12	12	719.56	11.31	11.33	360.48	12
14	623.09	8.480	8.491	311.99	14	14	722.89	11.42	11.44	362.15	14
16	626.42	8.570	8.581	313.66	16	16	726.21	11.52	11.54	363.83	16
18	629.74	8.660	8.671	315.33	18	18	729.53	11.63	11.65	365.50	18
20	633.07	8.750	8.761	317.00	20	20	732.86	11.73	11.75	367.17	20
22	636.40	8.844	8.856	318.67	22	22	736.19	11.84	11.86	368.85	22
24	639.72	8.939	8.951	320.34	24	24	739.51	11.95	11.97	370.52	24
26	643.05	9.033	9.046	322.01	26	26	742.84	12.06	12.08	372.19	26
28	646.38	9.128	9.141	323.68	28	28	746.17	12.17	12.19	373.86	28
30	649.70	9.222	9.236	325.35	30	30	749.49	12.27	12.30	375.54	30
32	653.03	9.317	9.331	327.02	32	32	752.82	12.38	12.41	377.22	32
34	656.36	9.411	9.426	328.69	34	34	756.15	12.49	12.52	378.89	34
36	659.69	9.506	9.521	330.37	36	36	759.47	12.60	12.63	380.57	36
38	663.02	9.600	9.616	332.04	38	38	762.80	12.71	12.74	382.24	38
40	666.34	9.695	9.712	333.71	40	40	766.13	12.82	12.85	383.92	40
42	669.67	9.794	9.812	335.38	42	42	769.45	12.93	12.96	385.60	42
44	673.00	9.894	9.912	337.05	44	44	772.78	13.04	13.08	387.27	44
46	676.32	9.993	10.01	338.73	46	46	776.11	13.15	13.19	388.95	46
48	679.65	10.09	10.11	340.40	48	48	779.43	13.26	13.31	390.62	48
50	682.98	10.19	10.21	342.07	50	50	782.76	13.37	13.42	392.30	50
52	686.30	10.29	10.31	343.74	52	52	786.09	13.48	13.53	393.98	52
54	689.63	10.39	10.41	345.41	54	54	789.41	13.59	13.65	395.65	54
56	692.96	10.49	10.51	347.08	56	56	792.74	13.70	13.76	397.33	56
58	696.28	10.59	10.61	348.76	58	58	796.07	13.81	13.88	399.01	58
60	699.60	10.69	10.71	350.44	60	60	799.40	13.96	13.99	400.70	60

			8°.						9°.		
Min.	Chord.	Mid. Ord.	Ex. Sec.	A. D.	Min.	Min.	Chord.	Mid. Ord.	Ex. Sec.	A. D.	Min.
0	799.40	13.95	13.98	400.70	0	0	899.10	17.66	17.71	450.95	0
2	802.72	14.07	14.10	402.37	2	2	902.42	17.79	17.84	452.64	2
4	806.04	14.19	14.22	404.05	4	4	905.74	17.92	17.98	454.31	4
6	809.37	14.31	14.34	405.72	6	6	909.07	18.06	18.11	455.98	6
8	812.69	14.43	14.46	407.39	8	8	912.39	18.19	18.25	457.66	8
10	816.01	14.55	14.58	409.06	10	10	915.71	18.32	18.38	459.34	10
12	819.34	14.66	14.70	410.74	12	12	919.04	18.46	18.52	461.02	12
14	822.66	14.78	14.82	412.41	14	14	922.36	18.59	18.65	462.70	14
16	825.98	14.90	14.94	414.08	16	16	925.68	18.72	18.79	464.37	16
18	829.31	15.02	15.06	415.75	18	18	929.01	18.86	18.92	466.05	18
20	832.63	15.14	15.18	417.43	20	20	932.33	18.99	19.06	467.73	20
22	835.95	15.26	15.30	419.10	22	22	935.65	19.12	19.19	469.41	22
24	839.28	15.38	15.43	420.77	24	24	938.98	19.26	19.33	471.08	24
26	842.60	15.51	15.55	422.45	26	26	942.30	19.40	19.47	472.76	26
28	845.92	15.63	15.68	424.12	28	28	945.62	19.54	19.61	474.44	28
30	849.25	15.75	15.80	425.79	30	30	948.95	19.68	19.75	476.11	30
32	852.57	15.88	15.93	427.47	32	32	952.27	19.82	19.89	477.78	32
34	855.89	16.00	16.05	429.15	34	34	955.59	19.96	20.03	479.46	34
36	859.22	16.12	16.18	430.82	36	36	958.91	20.10	20.17	481.14	36
38	862.54	16.25	16.30	432.50	38	38	962.24	20.24	20.31	482.83	38
40	865.86	16.38	16.43	434.18	40	40	965.56	20.38	20.45	484.51	40
42	869.19	16.50	16.55	435.86	42	42	968.89	20.52	20.59	486.19	42
44	872.51	16.63	16.68	437.54	44	44	972.21	20.66	20.74	487.87	44
46	875.83	16.76	16.81	439.21	46	46	975.53	20.80	20.88	489.56	46
48	879.16	16.89	16.94	440.89	48	48	978.86	20.94	21.03	491.24	48
50	882.48	17.02	17.07	442.57	50	50	982.18	21.09	21.17	492.92	50
52	885.80	17.14	17.19	444.25	52	52	985.50	21.23	21.31	494.60	52
54	889.13	17.27	17.32	445.93	54	54	988.83	21.37	21.46	496.28	54
56	892.45	17.40	17.45	447.60	56	56	992.15	21.51	21.60	497.96	56
58	895.77	17.53	17.58	449.28	58	58	995.47	21.65	21.75	499.65	58
60	899.10	17.66	17.71	450.95	60	60	998.80	21.80	21.89	501.34	60

	18°.					19°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	1792.7	70.54	71.42	907.52	0	0	1891.5	78.58	79.65	958.86	0
2	1796.0	70.80	71.69	909.23	2	2	1894.8	78.86	79.94	960.57	2
4	1799.3	71.06	71.96	910.94	4	4	1898.1	79.13	80 22	962.30	4
6	1802.6	71.33	72.23	912.65	6	6	1901.3	79.41	80.51	964.00	6
8	1805.9	71.59	72.50	914.36	8	8	1904.6	79.68	80.79	965.72	8
10	1809.2	71.85	72.77	916.07	10	10	1907.9	79.96	81.08	967.43	10
12	1812.5	72.12	73.04	917.78	12	12	1911.2	80.24	81.37	969.15	12
14	1815.7	72.38	73.31	919.49	14	14	1914.5	80.51	81.65	970.86	14
16	1819.0	72.64	73.58	921.20	16	16	1917.8	80.79	81.94	972.58	16
18	1822.3	72.91	73.85	922.91	18	18	1921.0	81.07	82.22	974.29	18
20	1825.6	73.17	74.12	924.63	20	20	1924.3	81.35	82.51	976.01	20
22	1828.9	73.43	74.39	926.34	22	22	1927.6	81.63	82.80	977.72	22
24	1832.2	73.70	74.67	928.05	24	24	1930.9	81.91	83.09	979.44	24
26	1835.5	73.97	74.94	929.76	26	26	1934.2	82.20	83.38	981.15	26
28	1838.8	74.24	75.22	931.47	28	28	1937.5	82.48	83.67	982.86	28
30	1842.1	74.51	75.49	933.18	30	30	1940.7	82.76	83.97	984.58	30
32	1845.4	74.77	75.77	934.89	32	32	1944.0	83.05	84.26	986.30	32
34	1848.7	75.04	76.04	936.60	34	34	1947.3	83.33	84.55	988.02	34
36	1852.0	75.31	76.32	938.32	36	36	1950.6	83.61	84.84	989.74	36
38	1855.3	75.58	76.59	940.03	38	38	1953.9	83.90	85.13	991.46	38
40	1858.6	75.85	76.87	941.74	40	40	1957.2	84.18	85.43	993.18	40
42	1861.9	76.12	77.14	943.45	42	42	1960.4	84.47	85.73	994.90	42
44	1865.1	76.39	77.42	945.16	44	44	1963.7	84.75	86.02	996.62	44
46	1868.4	76.67	77.70	946.88	46	46	1967.0	85.04	86.32	998.34	46
48	1871.7	76.94	77.98	948.59	48	48	1970.3	85.32	86.61	1000.0	48
50	1875.0	77.21	78.26	950.30	50	50	1973.6	85.61	86.91	1001.8	50
52	1878.3	77.49	78.53	952.01	52	52	1976.9	85.90	87.21	1003.5	52
54	1881.6	77.76	78.81	953.72	54	54	1980.1	86.19	87.50	1005.2	54
56	1884.9	78.03	79.09	955.44	56	56	1983.4	86.47	87.80	1006.9	56
58	1888.2	78.31	79.37	957.15	58	58	1986.7	86.76	88.09	1008.6	58
60	1891.5	78.58	79.65	958.86	60	60	1990.0	87.05	88.39	1010.4	60

	8°.					9°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	799.40	13.96	13.99	400.70	0	0	899.10	17.66	17.71	450.95	0
2	802.72	14.07	14.10	402.37	2	2	902.42	17.79	17.84	452.63	2
4	806.04	14.19	14.22	404.05	4	4	905.74	17.92	17.98	454.31	4
6	809.37	14.31	14.34	405.72	6	6	909.07	18.06	18.11	455.98	6
8	812.69	14.43	14.46	407.39	8	8	912.39	18.19	18.25	457.66	8
10	816.01	14.55	14.58	409.06	10	10	915.71	18.32	18.38	459.34	10
12	819.34	14.66	14.70	410.74	12	12	919.04	18.46	18.52	461.02	12
14	822.66	14.78	14.82	412.41	14	14	922.36	18.59	18.65	462.70	14
16	825.98	14.90	14.94	414.08	16	16	925.68	18.72	18.79	464.37	16
18	829.31	15.02	15.06	415.75	18	18	929.01	18.86	18.92	466.05	18
20	832.63	15.14	15.18	417.43	20	20	932.33	18.99	19.06	467.73	20
22	835.95	15.26	15.30	419.10	22	22	935.65	19.12	19.19	469.41	22
24	839.28	15.38	15.43	420.77	24	24	938.98	19.26	19.33	471.08	24
26	842.60	15.51	15.55	422.45	26	26	942.30	19.40	19.47	472.76	26
28	845.92	15.63	15.68	424.12	28	28	945.62	19.54	19.61	474.43	28
30	849.25	15.75	15.80	425.79	30	30	948.95	19.68	19.75	476.10	30
32	852.57	15.88	15.93	427.47	32	32	952.27	19.82	19.89	477.78	32
34	855.89	16.00	16.05	429.15	34	34	955.59	19.96	20.03	479.46	34
36	859.22	16.12	16.18	430.82	36	36	958.92	20.10	20.17	481.14	36
38	862.54	16.25	16.30	432.50	38	38	962.24	20.24	20.31	482.83	38
40	865.86	16.38	16.43	434.18	40	40	965.56	20.38	20.45	484.51	40
42	869.19	16.50	16.55	435.86	42	42	968.89	20.52	20.59	486.19	42
44	872.51	16.63	16.68	437.54	44	44	972.21	20.66	20.74	487.87	44
46	875.83	16.76	16.81	439.21	46	46	975.53	20.80	20.88	489.56	46
48	879.16	16.89	16.94	440.89	48	48	978.86	20.94	21.03	491.24	48
50	882.48	17.02	17.07	442.57	50	50	982.18	21.09	21.17	492.92	50
52	885.80	17.14	17.19	444.25	52	52	985.50	21.23	21.31	494.60	52
54	889.13	17.27	17.32	445.93	54	54	988.83	21.37	21.46	496.28	54
56	892.45	17.40	17.45	447.60	56	56	992.15	21.51	21.60	497.96	56
58	895.77	17.53	17.58	449.28	58	58	995.47	21.65	21.75	499.65	58
60	899.10	17.66	17.71	450.95	60	60	998.80	21.80	21.89	501.32	60

22°.						23°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	2186.7	105.2	107.2	1113.8	0	0	2284.8	115.0	117.4	1165.8	0
2	2190.0	105.6	107.6	1115.5	2	2	2288.1	115.3	117.7	1167.5	2
4	2193.2	105.9	107.9	1117.3	4	4	2291.3	115.7	118.1	1169.2	4
6	2196.5	106.2	108.2	1119.0	6	6	2294.6	116.0	118.4	1171.0	6
8	2199.8	106.5	108.6	1120.7	8	8	2297.8	116.4	118.8	1172.7	8
10	2203.0	106.8	108.9	1122.4	10	10	2301.1	116.7	119.1	1174.4	10
12	2206.3	107.1	109.2	1124.2	12	12	2304.4	117.0	119.5	1176.2	12
14	2209.6	107.4	109.6	1125.9	14	14	2307.6	117.4	119.8	1177.9	14
16	2212.9	107.7	109.9	1127.6	16	16	2310.9	117.7	120.2	1179.7	16
18	2216.1	108.0	110.2	1129.4	18	18	2314.1	118.1	120.5	1181.4	18
20	2219.4	108.4	110.6	1131.1	20	20	2317.4	118.4	120.9	1183.1	20
22	2222.7	108.7	110.9	1132.8	22	22	2320.7	118.7	121.2	1184.9	22
24	2225.9	109.0	111.2	1134.6	24	24	2323.9	119.1	121.6	1186.6	24
26	2229.2	109.4	111.6	1136.3	26	26	2327.2	119.4	121.9	1188.4	26
28	2232.5	109.7	111.9	1138.0	28	28	2330.4	119.8	122.3	1190.1	28
30	2235.7	110.0	112.3	1139.7	30	30	2333.7	120.1	122.6	1191.8	30
32	2239.0	110.4	112.6	1141.5	32	32	2337.0	120.4	123.0	1193.6	32
34	2242.3	110.7	112.9	1143.2	34	34	2340.2	120.8	123.3	1195.3	34
36	2245.6	111.0	113.3	1144.9	36	36	2343.5	121.1	123.7	1197.1	36
38	2248.8	111.4	113.6	1146.7	38	38	2346.7	121.5	124.1	1198.8	38
40	2252.1	111.7	113.9	1148.4	40	40	2350.0	121.8	124.4	1200.5	40
42	2255.4	112.0	114.3	1150.1	42	42	2353.3	122.1	124.8	1202.3	42
44	2258.6	112.3	114.6	1151.9	44	44	2356.5	122.5	125.1	1204.0	44
46	2261.9	112.7	115.0	1153.6	46	46	2359.8	122.8	125.5	1205.8	46
48	2265.2	113.0	115.3	1155.4	48	48	2363.0	123.2	125.8	1207.5	48
50	2268.4	113.3	115.7	1157.1	50	50	2366.3	123.5	126.2	1209.2	50
52	2271.7	113.7	116.0	1158.8	52	52	2369.6	123.8	126.6	1211.0	52
54	2275.0	114.0	116.3	1160.6	54	54	2372.8	124.2	126.9	1212.7	54
56	2278.3	114.3	116.7	1162.3	56	56	2376.1	124.5	127.3	1214.5	56
58	2281.5	114.7	117.0	1164.0	58	58	2379.3	124.9	127.6	1216.2	58
60	2284.8	115.0	117.4	1165.8	60	60	2382.6	125.2	128.0	1218.0	60

Min.	24°.					25°.					
Min.	Chord.	Mid. Ord.	Ex. Sec.	A. D.	Min.	Min.	Chord.	Mid. Ord.	Ex. Sec.	A. D.	Min.
0	2382.6	125.2	128.0	1218.0	0	0	2480.4	135.8	139.1	1270.3	0
2	2385.9	125.5	128.4	1219.7	2	2	2483.6	136.2	139.5	1272.0	2
4	2389.1	125.9	128.7	1221.4	4	4	2486.9	136.5	139.9	1273.8	4
6	2392.4	126.2	129.1	1223.2	6	6	2490.1	136.9	140.3	1275.5	6
8	2395.6	126.6	129.5	1224.9	8	8	2493.4	137.2	140.6	1277.3	8
10	2398.9	126.9	129.8	1226.7	10	10	2496.6	137.6	141.0	1279.0	10
12	2402.2	127.3	130.2	1228.4	12	12	2499.9	138.0	141.4	1280.8	12
14	2405.4	127.6	130.6	1230.2	14	14	2503.1	138.3	141.8	1282.5	14
16	2408.7	128.0	130.9	1231.9	16	16	2506.4	138.7	142.2	1284.3	16
18	2411.9	128.3	131.3	1233.6	18	18	2509.6	139.0	142.5	1286.1	18
20	2415.2	128.7	131.7	1235.4	20	20	2512.9	139.4	142.9	1287.8	20
22	2418.5	129.0	132.0	1237.1	22	22	2516.1	139.8	143.3	1289.6	22
24	2421.7	129.4	132.4	1238.9	24	24	2519.4	140.1	143.7	1291.3	24
26	2425.0	129.7	132.8	1240.6	26	26	2522.6	140.5	144.1	1293.1	26
28	2428.2	130.1	133.1	1242.4	28	28	2525.9	140.8	144.5	1294.8	28
30	2431.5	130.4	133.5	1244.1	30	30	2529.1	141.2	144.9	1296.6	30
32	2434.8	130.8	133.9	1245.8	32	32	2532.4	141.6	145.3	1298.3	32
34	2438.0	131.1	134.2	1247.6	34	34	2535.6	142.0	145.6	1300.1	34
36	2441.3	131.5	134.6	1249.3	36	36	2538.9	142.3	146.0	1301.8	36
38	2444.5	131.8	135.0	1251.1	38	38	2542.1	142.7	146.4	1303.6	38
40	2447.8	132.2	135.4	1252.8	40	40	2545.4	143.1	146.8	1305.3	40
42	2451.1	132.6	135.7	1254.6	42	42	2548.6	143.5	147.2	1307.1	42
44	2454.3	132.9	136.1	1256.3	44	44	2551.9	143.8	147.6	1308.8	44
46	2457.6	133.3	136.5	1258.1	46	46	2555.1	144.2	148.0	1310.6	46
48	2460.8	133.6	136.9	1259.8	48	48	2558.4	144.5	148.4	1312.4	48
50	2464.1	134.0	137.2	1261.5	50	50	2561.6	144.9	148.8	1314.1	50
52	2467.4	134.4	137.6	1263.3	52	52	2564.9	145.3	149.2	1315.9	52
54	2470.6	134.7	138.0	1265.0	54	54	2568.1	145.7	149.5	1317.6	54
56	2473.9	135.1	138.4	1266.8	56	56	2571.4	146.0	149.9	1319.4	56
58	2477.1	135.4	138.7	1268.5	58	58	2574.6	146.4	150.3	1321.1	58
60	2480.4	135.8	139.1	1270.3	60	60	2577.9	146.8	150.7	1322.9	60

14°.						15°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	1396.6	42.71	43.03	703.53	0	0	1495.9	49.02	49.44	754.35	0
2	1399.9	42.92	43.23	705.23	2	2	1499.2	49.24	49.66	756.05	2
4	1403.2	43.12	43.44	706.92	4	4	1502.5	49.46	49.89	757.74	4
6	1406.5	43.33	43.65	708.62	6	6	1505.8	49.68	50.11	759.44	6
8	1409.8	43.53	43.86	710.31	8	8	1509.1	49.90	50.34	761.13	8
10	1413.1	43.74	44.07	712.01	10	10	1512.4	50.12	50.56	762.83	10
12	1416.5	43.94	44.28	713.71	12	12	1515.7	50.34	50.78	764.53	12
14	1419.8	44.15	44.49	715.40	14	14	1519.0	50.56	51.01	766.22	14
16	1423.1	44.35	44.70	717.10	16	16	1522.3	50.78	51.23	767.92	16
18	1426.4	44.56	44.91	718.79	18	18	1525.6	51.00	51.46	769.61	18
20	1429.7	44.77	45.12	720.49	20	20	1528.9	51.22	51.68	771.31	20
22	1433.0	44.98	45.33	722.20	22	22	1532.2	51.44	51.90	773.01	22
24	1436.3	45.19	45.54	723.89	24	24	1535.5	51.67	52.13	774.70	24
26	1439.6	45.40	45.76	725.59	26	26	1538.8	51.89	52.36	776.40	26
28	1442.9	45.61	45.97	727.28	28	28	1542.1	52.12	52.59	778.09	28
30	1446.2	45.82	46.18	728.97	30	30	1545.4	52.34	52.82	779.79	30
32	1449.6	46.03	46.40	730.66	32	32	1548.7	52.57	53.05	781.49	32
34	1452.9	46.24	46.61	732.35	34	34	1552.0	52.79	53.28	783.19	34
36	1456.2	46.45	46.82	734.05	36	36	1555.3	53.02	53.51	784.89	36
38	1459.5	46.66	47.04	735.74	38	38	1558.6	53.24	53.74	786.59	38
40	1462.8	46.87	47.25	737.43	40	40	1561.9	53.47	53.97	788.29	40
42	1466.1	47.08	47.46	739.12	42	42	1565.2	53.69	54.20	789.99	42
44	1469.4	47.30	47.68	740.81	44	44	1568.5	53.92	54.44	791.69	44
46	1472.7	47.51	47.90	742.51	46	46	1571.8	54.15	54.67	793.39	46
48	1476.0	47.73	48.12	744.20	48	48	1575.1	54.38	54.91	795.09	48
50	1479.3	47.94	48.34	745.89	50	50	1578.4	54.61	55.14	796.79	50
52	1482.7	48.16	48.56	747.58	52	52	1581.7	54.84	55.37	798.49	52
54	1486.0	48.37	48.78	749.27	54	54	1585.0	55.07	55.61	800.19	54
56	1489.3	48.59	49.00	750.97	56	56	1588.3	55.30	55.84	801.89	56
58	1492.6	48.80	49.22	752.66	58	58	1591.6	55.53	56.08	803.59	58
60	1495.9	49.02	49.44	754.35	60	60	1594.9	55.76	56.31	805.29	60

	16°.					17°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	1594.9	55.76	56.31	805.29	0	0	1693.9	62.94	63.64	856.35	0
2	1598.2	55.99	56.54	806.99	2	2	1697.2	63.18	63.89	858.05	2
4	1601.5	56.23	56.78	808.64	4	4	1700.5	63.43	64.15	859.76	4
6	1604.8	56.46	57.02	810.39	6	6	1703.8	63.68	64.40	861.46	6
8	1608.1	56.70	57.26	812.09	8	8	1707.1	63.93	64.66	863.16	8
10	1611.4	56.93	57.50	813.79	10	10	1710.4	64.18	64.91	864.87	10
12	1614.7	57.17	57.74	815.49	12	12	1713.7	64.42	65.16	866.57	12
14	1618.0	57.40	57.98	817.19	14	14	1716.9	64.67	65.42	868.27	14
16	1621.3	57.64	58.22	818.89	16	16	1720.2	64.92	65.67	869.98	16
18	1624.6	57.87	58.46	820.59	18	18	1723.5	65.17	65.93	871.68	18
20	1627.9	58.11	58.70	822.29	20	20	1726.8	65.42	66.18	873.38	20
22	1631.2	58.34	58.94	823.99	22	22	1730.1	65.67	66.43	875.09	22
24	1634.5	58.58	59.19	825.69	24	24	1733.4	65.93	66.69	876.79	24
26	1637.8	58.82	59.43	827.39	26	26	1736.7	66.18	66.95	878.49	26
28	1641.1	59.06	59.68	829.09	28	28	1740.0	66.44	67.21	880.20	28
30	1644.4	59.30	59.92	830.79	30	30	1743.3	66.69	67.47	881.90	30
32	1647.7	59.54	60.16	832.49	32	32	1746.6	66.94	67.72	883.61	32
34	1651.0	59.78	60.41	834.20	34	34	1749.9	67.20	67.98	885.32	34
36	1654.3	60.02	60.65	835.90	36	36	1753.2	67.45	68.24	887.02	36
38	1657.6	60.26	60.90	837.61	38	38	1756.5	67.71	68.50	888.73	38
40	1660.9	60.50	61.14	839.31	40	40	1759.8	67.96	68.76	890.44	40
42	1664.2	60.74	61.39	841.01	42	42	1763.1	68.21	69.03	892.15	42
44	1667.5	60.99	61.64	842.72	44	44	1766.3	68.47	69.29	893.86	44
46	1670.8	61.23	61.89	844.42	46	46	1769.6	68.73	69.56	895.56	46
48	1674.1	61.48	62.14	846.13	48	48	1772.9	68.99	69.82	897.27	48
50	1677.4	61.72	62.39	847.83	50	50	1776.2	69.25	70.09	898.98	50
52	1680.7	61.96	62.64	849.53	52	52	1779.5	69.50	70.36	900.69	52
54	1684.0	62.21	62.89	851.24	54	54	1782.8	69.76	70.62	902.40	54
56	1687.3	62.45	63.14	852.94	56	56	1786.1	70.02	70.89	904.10	56
58	1690.6	62.70	63.39	854.65	58	58	1789.4	70.28	71.15	905.81	58
60	1693.9	62.94	63.64	856.35	60	60	1792.7	70.54	71.42	907.52	60

	18°.					19°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	1792.7	70.54	71.42	907.52	0	0	1891.5	78.58	79.65	958.86	0
2	1796.0	70.80	71.69	909.23	2	2	1894.8	78.86	79.94	960.57	2
4	1799.3	71.06	71.96	910.94	4	4	1898.1	79.13	80.22	962.30	4
6	1802.6	71.33	72.23	912.65	6	6	1901.3	79.41	80.51	964.00	6
8	1805.9	71.59	72.50	914.36	8	8	1904.6	79.68	80.79	965.72	8
10	1809.2	71.85	72.77	916.07	10	10	1907.9	79.96	81.08	967.43	10
12	1812.5	72.12	73.04	917.78	12	12	1911.2	80.24	81.37	969.15	12
14	1815.7	72.38	73.31	919.49	14	14	1914.5	80.51	81.65	970.86	14
16	1819.0	72.64	73.58	921.20	16	16	1917.8	80.79	81.94	972.58	16
18	1822.3	72.91	73.85	922.91	18	18	1921.0	81.07	82.22	974.29	18
20	1825.6	73.17	74.12	924.63	20	20	1924.3	81.35	82.51	976.01	20
22	1828.9	73.43	74.39	926.34	22	22	1927.6	81.63	82.80	977.72	22
24	1832.2	73.70	74.67	928.05	24	24	1930.9	81.91	83.09	979.44	24
26	1835.5	73.97	74.94	929.76	26	26	1934.2	82.20	83.38	981.15	26
28	1838.8	74.24	75.22	931.47	28	28	1937.5	82.48	83.67	982.86	28
30	1842.1	74.51	75.49	933.18	30	30	1940.7	82.76	83.97	984.58	30
32	1845.4	74.77	75.77	934.89	32	32	1944.0	83.05	84.26	986.30	32
34	1848.7	75.04	76.04	936.60	34	34	1947.3	83.33	84.55	988.02	34
36	1852.0	75.31	76.32	938.32	36	36	1950.6	83.61	84.84	989.74	36
38	1855.3	75.58	76.59	940.03	38	38	1953.9	83.90	85.13	991.46	38
40	1858.6	75.85	76.87	941.74	40	40	1957.2	84.18	85.43	993.18	40
42	1861.9	76.12	77.14	943.45	42	42	1960.4	84.47	85.73	994.90	42
44	1865.1	76.39	77.42	945.16	44	44	1963.7	84.75	86.02	996.62	44
46	1868.4	76.67	77.70	946.88	46	46	1967.0	85.04	86.32	998.34	46
48	1871.7	76.94	77.98	948.59	48	48	1970.3	85.32	86.61	1000.0	48
50	1875.0	77.21	78.26	950.30	50	50	1973.6	85.61	86.91	1001.8	50
52	1878.3	77.49	78.53	952.01	52	52	1976.9	85.90	87.21	1003.5	52
54	1881.6	77.76	78.81	953.72	54	54	1980.1	86.19	87.50	1005.2	54
56	1884.9	78.03	79.09	955.44	56	56	1983.4	86.47	87.80	1006.9	56
58	1888.2	78.31	79.37	957.15	58	58	1986.7	86.76	88.09	1008.6	58
60	1891.5	78.58	79.65	958.86	60	60	1990.0	87.05	88.39	1010.4	60

	24°.					25°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	2382.6	125.2	128.0	1218.0	0	0	2480.4	135.8	139.1	1270.3	0
2	2385.9	125.5	128.4	1219.7	2	2	2483.6	136.2	139.5	1272.0	2
4	2389.1	125.9	128.7	1221.4	4	4	2486.9	136.5	139.9	1273.8	4
6	2392.4	126.2	129.1	1223.2	6	6	2490.1	136.9	140.3	1275.5	6
8	2395.6	126.6	129.5	1224.9	8	8	2493.4	137.2	140.6	1277.3	8
10	2398.9	126.9	129.8	1226.7	10	10	2496.6	137.6	141.0	1279.0	10
12	2402.2	127.3	130.2	1228.4	12	12	2499.9	138.0	141.4	1280.8	12
14	2405.4	127.6	130.6	1230.2	14	14	2503.1	138.3	141.8	1282.5	14
16	2408.7	128.0	130.9	1231.9	16	16	2506.4	138.7	142.2	1284.3	16
18	2411.9	128.3	131.3	1233.6	18	18	2509.6	139.0	142.5	1286.1	18
20	2415.2	128.7	131.7	1235.4	20	20	2512.9	139.4	142.9	1287.8	20
22	2418.5	129.0	132.0	1237.1	22	22	2516.1	139.8	143.3	1289.6	22
24	2421.7	129.4	132.4	1238.9	24	24	2519.4	140.1	143.7	1291.3	24
26	2425.0	129.7	132.8	1240.6	26	26	2522.6	140.5	144.1	1293.1	26
28	2428.2	130.1	133.1	1242.4	28	28	2525.9	140.8	144.5	1294.8	28
30	2431.5	130.4	133.5	1244.1	30	30	2529.1	141.2	144.9	1296.6	30
32	2434.8	130.8	133.9	1245.8	32	32	2532.4	141.6	145.3	1298.3	32
34	2438.0	131.1	134.2	1247.6	34	34	2535.6	142.0	145.6	1300.1	34
36	2441.3	131.5	134.6	1249.3	36	36	2538.9	142.3	146.0	1301.8	36
38	2444.5	131.8	135.0	1251.1	38	38	2542.1	142.7	146.4	1303.6	38
40	2447.8	132.2	135.4	1252.8	40	40	2545.4	143.1	146.8	1305.3	40
42	2451.1	132.6	135.7	1254.6	42	42	2548.6	143.5	147.2	1307.1	42
44	2454.3	132.9	136.1	1256.3	44	44	2551.9	143.8	147.6	1308.8	44
46	2457.6	133.3	136.5	1258.1	46	46	2555.1	144.2	148.0	1310.6	46
48	2460.8	133.6	136.9	1259.8	48	48	2558.4	144.5	148.4	1312.4	48
50	2464.1	134.0	137.2	1261.5	50	50	2561.6	144.9	148.8	1314.1	50
52	2467.4	134.4	137.6	1263.3	52	52	2564.9	145.3	149.2	1315.9	52
54	2470.6	134.7	138.0	1265.0	54	54	2568.1	145.7	149.5	1317.6	54
56	2473.9	135.1	138.4	1266.8	56	56	2571.4	146.0	149.9	1319.4	56
58	2477.1	135.4	138.7	1268.5	58	58	2574.6	146.4	150.3	1321.1	58
60	2480.4	135.8	139.1	1270.3	60	60	2577.9	146.8	150.7	1322.9	60

26°.						27°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	2577.9	146.8	150.7	1322.9	0	0	2675.3	158.3	162.8	1375.6	0
2	2581.1	147.1	151.1	1324.6	2	2	2678.5	158.6	163.2	1377.4	2
4	2584.4	147.5	151.5	1326.4	4	4	2681.8	159.0	163.7	1379.2	4
6	2587.6	147.9	151.9	1328.1	6	6	2685.0	159.4	164.1	1380.9	6
8	2590.9	148.3	152.3	1329.9	8	8	2688.2	159.8	164.5	1382.7	8
10	2594.1	148.7	152.7	1331.6	10	10	2691.5	160.2	164.9	1384.5	10
12	2597.4	149.1	153.1	1333.4	12	12	2694.7	160.6	165.3	1386.2	12
14	2600.6	149.4	153.5	1335.2	14	14	2698.0	161.0	165.7	1388.0	14
16	2603.9	149.8	153.9	1336.9	16	16	2701.2	161.4	166.1	1389.8	16
18	2607.1	150.2	154.3	1338.7	18	18	2704.4	161.8	166.5	1391.5	18
20	2610.4	150.6	154.7	1340.4	20	20	2707.7	162.2	167.0	1393.3	20
22	2613.6	151.0	155.1	1342.2	22	22	2710.9	162.6	167.4	1395.0	22
24	2616.9	151.4	155.5	1343.9	24	24	2714.1	163.0	167.8	1396.8	24
26	2620.1	151.7	155.9	1345.7	26	26	2717.4	163.4	168.2	1398.6	26
28	2623.4	152.1	156.3	1347.4	28	28	2720.6	163.8	168.6	1400.3	28
30	2626.6	152.5	156.7	1349.2	30	30	2723.8	164.2	169.1	1402.1	30
32	2629.8	152.9	157.1	1351.0	32	32	2727.1	164.6	169.5	1403.9	32
34	2633.1	153.3	157.5	1352.7	34	34	2730.3	165.0	169.9	1405.6	34
36	2636.3	153.7	157.9	1354.5	36	36	2733.6	165.4	170.3	1407.4	36
38	2639.6	154.0	158.3	1356.2	38	38	2736.8	165.8	170.8	1409.2	38
40	2642.8	154.4	158.7	1358.0	40	40	2740.0	166.2	171.2	1410.9	40
42	2646.1	154.8	159.1	1359.8	42	42	2743.3	166.6	171.6	1412.7	42
44	2649.3	155.2	159.5	1361.5	44	44	2746.5	167.0	172.0	1414.5	44
46	2652.6	155.6	160.0	1363.3	46	46	2749.7	167.4	172.5	1416.3	46
48	2655.8	156.0	160.4	1365.1	48	48	2753.0	167.8	172.9	1418.0	48
50	2659.1	156.3	160.8	1366.8	50	50	2756.2	168.2	173.3	1419.8	50
52	2662.3	156.7	161.2	1368.6	52	52	2759.5	168.6	173.7	1421.6	52
54	2665.6	157.1	161.6	1370.4	54	54	2762.7	169.0	174.1	1423.3	54
56	2668.8	157.5	162.0	1372.1	56	56	2765.9	169.4	174.6	1425.1	56
58	2672.1	157.9	162.4	1373.9	58	58	2769.2	169.8	175.0	1426.9	58
60	2675.3	158.3	162.8	1375.6	60	60	2772.4	170.2	175.4	1428.6	60

	36°.					37°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	3541.4	280.4	294.9	1861.8	0	0	3636.3	296.1	312.3	1917.3	0
2	3544.6	280.9	295.4	1863.6	2	2	3639.5	296.6	312.8	1919.1	2
4	3547.7	281.4	296.0	1865.5	4	4	3642.6	297.1	313.4	1921.0	4
6	3550.9	281.9	296.6	1867.3	6	6	3645.8	297.7	314.0	1922.8	6
8	3554.0	282.5	297.2	1869.2	8	8	3648.9	298.2	314.6	1924.7	8
10	3557.2	283.0	297.7	1871.0	10	10	3652.1	298.7	315.2	1926.5	10
12	3560.4	283.5	298.3	1872.9	12	12	3655.2	299.3	315.8	1928.4	12
14	3563.5	284.0	298.9	1874.7	14	14	3658.4	299.8	316.4	1930.2	14
16	3566.7	284.6	299.5	1876.5	16	16	3661.6	300.3	317.0	1932.1	16
18	3569.9	285.1	300.0	1878.4	18	18	3664.7	300.9	317.5	1933.9	18
20	3573.0	285.6	300.6	1880.2	20	20	3667.9	301.4	318.1	1935.8	20
22	3576.2	286.1	301.2	1882.1	22	22	3671.0	301.9	318.7	1937.6	22
24	3579.4	286.7	301.8	1883.9	24	24	3674.2	302.5	319.3	1939.5	24
26	3582.5	287.2	302.3	1885.8	26	26	3677.3	303.0	319.9	1941.3	26
28	3585.7	287.7	302.9	1887.6	28	28	3680.5	303.5	320.5	1943.2	28
30	3588.8	288.2	303.5	1889.5	30	30	3683.6	304.1	321.1	1945.0	30
32	3592.0	288.8	304.1	1891.3	32	32	3686.8	304.6	321.7	1946.9	32
34	3595.2	289.3	304.6	1893.2	34	34	3690.0	305.1	322.3	1948.8	34
36	3598.3	289.8	305.2	1895.0	36	36	3693.1	305.7	322.9	1950.6	36
38	3601.5	290.3	305.8	1896.9	38	38	3696.3	306.2	323.5	1952.5	38
40	3604.7	290.9	306.4	1898.7	40	40	3699.4	306.7	324.2	1954.4	40
42	3607.8	291.4	307.0	1900.6	42	42	3702.6	307.3	324.8	1956.2	42
44	3611.0	291.9	307.5	1902.4	44	44	3705.7	307.8	325.4	1958.1	44
46	3614.1	292.4	308.1	1904.3	46	46	3708.9	308.3	326.0	1960.0	46
48	3617.3	293.0	308.7	1906.1	48	48	3712.1	308.9	326.6	1961.8	48
50	3620.5	293.5	309.3	1908.0	50	50	3715.2	309.4	327.2	1963.7	50
52	3623.6	294.0	309.9	1909.8	52	52	3718.4	309.9	327.8	1965.5	52
54	3626.8	294.5	310.5	1911.7	54	54	3721.5	310.5	328.4	1967.4	54
56	3630.0	295.1	311.1	1913.5	56	56	3724.7	311.0	329.0	1969.3	56
58	3633.1	295.6	311.7	1915.4	58	58	3727.8	311.6	329.6	1971.1	58
60	3636.3	296.1	312.3	1917.3	60	60	3731.0	312.2	330.2	1973.0	60

30°.						31°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	2966.1	195.2	202.1	1535.3	0	0	3062.6	208.4	216.3	1589.0	0
2	2969.3	195.6	202.6	1537.1	2	2	3065.8	208.8	216.8	1590.8	2
4	2972.5	196.1	203.1	1538.9	4	4	3069.0	209.3	217.2	1592.6	4
6	2975.7	196.5	203.5	1540.7	6	6	3072.2	209.7	217.7	1594.4	6
8	2979.0	197.0	204.0	1542.5	8	8	3075.4	210.2	218.2	1596.2	8
10	2982.2	197.4	204.5	1544.3	10	10	3078.6	210.6	218.7	1598.0	10
12	2985.4	197.8	204.9	1546.0	12	12	3081.8	211.1	219.2	1599.8	12
14	2988.6	198.2	205.4	1547.8	14	14	3085.0	211.5	219.6	1601.6	14
16	2991.8	198.6	205.9	1549.6	16	16	3088.3	212.0	220.1	1603.4	16
18	2995.0	199.1	206.3	1551.4	18	18	3091.5	212.4	220.6	1605.2	18
20	2998.3	199.5	206.8	1553.2	20	20	3094.7	212.9	222.1	1607.0	20
22	3001.5	199.9	207.3	1555.0	22	22	3097.9	213.3	221.6	1608.8	22
24	3004.7	200.4	207.7	1556.8	24	24	3101.1	213.8	221.1	1610.6	24
26	3007.9	200.8	208.2	1558.6	26	26	3104.3	214.2	222.6	1612.4	26
28	3011.1	201.3	208.7	1560.4	28	28	3107.5	214.7	223.0	1614.2	28
30	3014.3	201.7	209.1	1562.2	30	30	3110.7	215.1	223.5	1616.0	30
32	3017.6	202.1	209.6	1564.0	32	32	3113.9	215.6	224.0	1617.8	32
34	3020.8	202.6	210.1	1565.7	34	34	3117.1	216.0	224.5	1619.6	34
36	3024.0	203.0	210.5	1567.5	36	36	3120.3	216.5	225.0	1621.4	36
38	3027.2	203.5	211.0	1569.3	38	38	3123.5	216.9	225.5	1623.2	38
40	3030.4	203.9	211.5	1571.1	40	40	3126.7	217.4	226.0	1625.9	40
42	3033.6	204.3	212.0	1572.9	42	42	3129.9	217.8	226.5	1626.8	42
44	3036.9	204.8	212.4	1574.7	44	44	3133.1	218.3	227.0	1628.6	44
46	3040.1	205.2	212.9	1576.5	46	46	3136.4	218.7	227.5	1630.5	46
48	3043.3	205.7	213.4	1578.3	48	48	3139.6	219.2	228.0	1632.3	48
50	3046.5	206.1	213.9	1580.1	50	50	3142.8	219.6	228.4	1634.1	50
52	3049.7	206.5	214.4	1581.9	52	52	3146.0	220.1	228.9	1635.9	52
54	3052.9	207.0	214.8	1583.7	54	54	3149.2	220.5	229.4	1637.7	54
56	3056.2	207.4	215.3	1585.5	56	56	3152.4	221.0	229.9	1639.5	56
58	3059.4	207.9	215.8	1587.2	58	58	3155.6	221.5	230.4	1641.3	58
60	3062.6	208.4	216.3	1589.0	60	60	3158.8	222.0	230.9	1643.1	60

	40°.					41°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	3919.5	345.6	367.7	2085.5	0	0	4013.4	362.9	387.4	2142.3	0
2	3922.6	346.1	368.4	2087.4	2	2	4016.5	363.4	388.1	2144.2	2
4	3925.8	346.7	369.0	2089.3	4	4	4019.6	364.0	388.8	2146.1	4
6	3928.9	347.2	369.7	2091.2	6	6	4022.7	364.5	389.4	2148.0	6
8	3932.0	347.8	370.3	2093.1	8	8	4025.9	365.1	390.1	2149.9	8
10	3935.1	348.4	371.0	2095.0	10	10	4029.0	365.6	390.7	2151.9	10
12	3938.3	348.9	371.6	2096.9	12	12	4032.1	366.2	391.4	2153.8	12
14	3941.4	349.5	372.3	2098.8	14	14	4035.2	366.8	392.1	2155.7	14
16	3944.5	350.1	372.9	2100.7	16	16	4038.3	367.4	392.7	2157.6	16
18	3947.7	350.7	373.6	2102.6	18	18	4041.4	368.0	393.4	2159.5	18
20	3950.8	351.3	374.3	2104.5	20	20	4044.6	368.6	394.1	2161.4	20
22	3953.9	351.8	374.9	2106.3	22	22	4047.7	369.2	394.7	2163.3	22
24	3957.1	352.4	375.6	2108.2	24	24	4050.8	369.8	395.4	2165.2	24
26	3960.2	353.0	376.2	2110.1	26	26	4053.9	370.4	396.1	2167.1	26
28	3963.3	353.6	376.9	2112.0	28	28	4057.0	371.0	396.8	2169.0	28
30	3966.4	354.2	377.5	2113.9	30	30	4060.1	371.6	397.5	2170.9	30
32	3969.6	354.7	378.2	2115.8	32	32	4063.3	372.2	398.1	2172.8	32
34	3972.7	355.3	378.8	2117.7	34	34	4066.4	372.8	398.8	2174.7	34
36	3975.8	355.9	379.5	2119.6	36	36	4069.5	373.4	399.5	2176.6	36
38	3979.0	356.5	380.1	2121.5	38	38	4072.6	374.0	400.2	2178.5	38
40	3982.1	357.1	380.8	2123.4	40	40	4075.7	374.6	400.9	2180.4	40
42	3985.2	357.6	381.4	2125.3	42	42	4078.8	375.2	401.5	2182.4	42
44	3988.4	358.2	382.1	2127.2	44	44	4082.0	375.8	402.2	2184.3	44
46	3991.5	358.8	382.8	2129.1	46	46	4085.1	376.4	402.9	2186.2	46
48	3994.6	359.4	383.4	2131.0	48	48	4088.2	377.0	403.6	2188.1	48
50	3997.7	360.0	384.1	2132.9	50	50	4091.3	377.6	404.3	2190.0	50
52	4000.9	360.5	384.8	2134.7	52	52	4094.4	378.2	404.9	2191.9	52
54	4004.0	361.1	385.4	2136.6	54	54	4097.5	378.8	405.6	2193.8	54
56	4007.1	361.7	386.1	2138.5	56	56	4100.7	379.4	406.3	2195.7	56
58	4010.3	362.3	386.8	2140.4	58	58	4103.8	380.0	407.0	2197.6	58
60	4013.4	362.9	387.4	2142.3	60	60	4106.9	380.6	407.7	2199.5	60

34°.						35°.					
Min.	Chord.	Mid. Ord.	Ex. Sec.	A. D.	Min.	Min.	Chord.	Mid. Ord.	Ex. Sec.	A. D.	Min.
0	3350.6	250.4	261.8	1751.8	0	0	3446.1	265.2	278.1	1806.7	0
2	3353.8	250.8	262.3	1753.7	2	2	3449.3	265.7	278.6	1808.5	2
4	3357.0	251.2	262.9	1755.5	4	4	3452.5	266.2	279.2	1810.3	4
6	3360.1	251.7	263.4	1757.3	6	6	3455.6	266.7	279.7	1812.2	6
8	3363.3	252.2	264.0	1759.1	8	8	3458.8	267.2	280.3	1814.0	8
10	3366.5	252.7	264.5	1761.0	10	10	3462.0	267.7	280.8	1815.8	10
12	3369.7	253.2	265.0	1762.8	12	12	3465.2	268.2	281.4	1817.7	12
14	3372.9	253.7	265.6	1764.6	14	14	3468.3	268.7	281.9	1819.5	14
16	3376.1	254.2	266.1	1766.4	16	16	3471.5	269.2	282.5	1821.3	16
18	3379.2	254.7	266.7	1768.3	18	18	3474.7	269.7	283.0	1823.2	18
20	3382.4	255.2	267.2	1770.1	20	20	3477.9	270.2	283.6	1825.0	20
22	3385.6	255.7	267.7	1771.9	22	22	3481.0	270.7	284.2	1826.8	22
24	3388.8	256.2	268.3	1773.7	24	24	3484.2	271.2	284.7	1828.7	24
26	3392.0	256.7	268.8	1775.6	26	26	3487.4	271.7	285.3	1830.5	26
28	3395.2	257.2	269.3	1777.4	28	28	3490.6	272.2	285.9	1832.3	28
30	3398.3	257.7	269.9	1779.2	30	30	3493.7	272.7	286.4	1834.2	30
32	3401.5	258.2	270.4	1781.0	32	32	3496.9	273.2	287.0	1836.0	32
34	3404.7	258.7	271.0	1782.9	34	34	3500.1	273.7	287.5	1837.8	34
36	3407.9	259.2	271.5	1784.7	36	36	3503.3	274.2	288.1	1839.7	36
38	3411.1	259.7	272.0	1786.5	38	38	3506.5	274.7	288.7	1841.5	38
40	3414.3	260.2	272.6	1788.4	40	40	3509.6	275.2	289.2	1843.4	40
42	3417.4	260.7	273.1	1790.2	42	42	3512.8	275.7	289.8	1845.2	42
44	3420.6	261.2	273.7	1792.0	44	44	3516.0	276.2	290.4	1847.1	44
46	3423.8	261.7	274.2	1793.9	46	46	3519.2	276.7	290.9	1848.9	46
48	3427.0	262.2	274.8	1795.7	48	48	3522.3	277.2	291.5	1850.7	48
50	3430.2	262.7	275.3	1797.5	50	50	3525.5	277.7	292.0	1852.6	50
52	3433.4	263.2	275.9	1799.3	52	52	3528.7	278.2	292.6	1854.4	52
54	3436.5	263.7	276.4	1801.2	54	54	3531.9	278.7	293.2	1856.3	54
56	3439.7	264.2	277.0	1803.0	56	56	3535.0	279.2	293.7	1858.1	56
58	3442.9	264.7	277.5	1804.8	58	58	3538.2	279.8	294.3	1859.9	58
60	3446.1	265.2	278.1	1806.7	60	60	3541.4	280.4	294.9	1861.8	60

MIN.	36°.					37°.					
	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	3541.4	280.4	294.9	1861.8	0	0	3636.3	296.1	312.3	1917.3	0
2	3544.6	280.9	295.4	1863.6	2	2	3639.5	296.6	312.8	1919.1	2
4	3547.7	281.4	296.0	1865.5	4	4	3642.6	297.1	313.4	1921.0	4
6	3550.9	281.9	296.6	1867.3	6	6	3645.8	297.7	314.0	1922.8	6
8	3554.0	282.5	297.2	1869.2	8	8	3648.9	298.2	314.6	1924.7	8
10	3557.2	283.0	297.7	1871.0	10	10	3652.1	298.7	315.2	1926.5	10
12	3560.4	283.5	298.3	1872.9	12	12	3655.2	299.3	315.8	1928.4	12
14	3563.5	284.0	298.9	1874.7	14	14	3658.4	299.8	316.4	1930.2	14
16	3566.7	284.6	299.5	1876.5	16	16	3661.6	300.3	317.0	1932.1	16
18	3569.9	285.1	300.0	1878.4	18	18	3664.7	300.9	317.5	1933.9	18
20	3573.0	285.6	300.6	1880.2	20	20	3667.9	301.4	318.1	1935.8	20
22	3576.2	286.1	301.2	1882.1	22	22	3671.0	301.9	318.7	1937.6	22
24	3579.4	286.7	301.8	1883.9	24	24	3674.2	302.5	319.3	1939.5	24
26	3582.5	287.2	302.3	1885.8	26	26	3677.3	303.0	319.9	1941.3	26
28	3585.7	287.7	302.9	1887.6	28	28	3680.5	303.5	320.5	1943.2	28
30	3588.8	288.2	303.5	1889.5	30	30	3683.6	304.1	321.1	1945.0	30
32	3592.0	288.8	304.1	1891.3	32	32	3686.8	304.6	321.7	1946.9	32
34	3595.2	289.3	304.6	1893.2	34	34	3690.0	305.1	322.3	1948.8	34
36	3598.3	289.8	305.2	1895.0	36	36	3693.1	305.7	322.9	1950.6	36
38	3601.5	290.3	305.8	1896.9	38	38	3696.3	306.2	323.5	1952.5	38
40	3604.7	290.9	306.4	1898.7	40	40	3699.4	306.7	324.2	1954.4	40
42	3607.8	291.4	307.0	1900.6	42	42	3702.6	307.3	324.8	1956.2	42
44	3611.0	291.9	307.5	1902.4	44	44	3705.7	307.8	325.4	1958.1	44
46	3614.1	292.4	308.1	1904.3	46	46	3708.9	308.3	326.0	1960.0	46
48	3617.3	293.0	308.7	1906.1	48	48	3712.1	308.9	326.6	1961.8	48
50	3620.5	293.5	309.3	1908.0	50	50	3715.2	309.4	327.2	1963.7	50
52	3623.6	294.0	309.9	1909.8	52	52	3718.4	309.9	327.8	1965.5	52
54	3626.8	294.5	310.5	1911.7	54	54	3721.5	310.5	328.4	1967.4	54
56	3630.0	295.1	311.1	1913.5	56	56	3724.7	311.0	329.0	1969.3	56
58	3633.1	295.6	311.7	1915.4	58	58	3727.8	311.6	329.6	1971.1	58
60	3636.3	296.1	312.3	1917.3	60	60	3731.0	312.2	330.2	1973.0	60

	38°.						39°.				
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	3731.0	312.2	330.2	1973.0	0	0	3825.5	328.7	348.7	2029.1	0
2	3734.1	312.7	330.8	1974.9	2	2	3828.6	329.2	349.3	2031.0	2
4	3737.3	313.3	331.4	1976.7	4	4	3831.8	329.8	349.9	2032.9	4
6	3740.4	313.8	332.0	1978.6	6	6	3834.9	330.3	350.6	2034.7	6
8	3743.6	314.4	332.6	1980.5	8	8	3838.0	330.9	351.2	2036.6	8
10	3746.7	314.9	333.2	1982.3	10	10	3841.2	331.5	351.8	2038.5	10
12	3749.9	315.5	333.8	1984.2	12	12	3844.3	332.0	352.4	2040.4	12
14	3753.0	316.0	334.5	1986.1	14	14	3847.4	332.6	353.1	2042.3	14
16	3756.2	316.6	335.1	1987.9	16	16	3850.6	333.2	353.7	2044.1	16
18	3759.3	317.1	335.7	1989.8	18	18	3853.7	333.7	354.3	2046.0	18
20	3762.5	317.7	336.3	1991.7	20	20	3856.8	334.3	354.9	2047.9	20
22	3765.6	318.2	336.9	1993.6	22	22	3860.0	334.9	355.6	2049.8	22
24	3768.8	318.8	337.5	1995.4	24	24	3863.1	335.4	356.2	2051.7	24
26	3771.9	319.3	338.1	1997.3	26	26	3866.2	336.0	356.9	2053.5	26
28	3775.1	319.9	338.7	1999.2	28	28	3869.4	336.6	357.5	2055.4	28
30	3778.2	320.4	339.4	2001.0	30	30	3872.5	337.1	358.1	2057.3	30
32	3781.4	321.0	340.0	2002.9	32	32	3875.6	337.7	358.8	2059.2	32
34	3784.5	321.5	340.6	2004.8	34	34	3878.8	338.3	359.4	2061.1	34
36	3787.7	322.1	341.2	2006.6	36	36	3881.9	338.8	360.1	2063.0	36
38	3790.8	322.6	341.8	2008.5	38	38	3885.0	339.4	360.7	2064.8	38
40	3794.0	323.2	342.4	2010.4	40	40	3888.2	340.0	361.3	2066.7	40
42	3797.1	323.7	343.1	2012.3	42	42	3891.3	340.5	362.0	2068.6	42
44	3800.3	324.3	343.7	2014.1	44	44	3894.4	341.1	362.6	2070.5	44
46	3803.4	324.8	344.3	2016.0	46	46	3897.6	341.7	363.3	2072.4	46
48	3806.6	325.4	344.9	2017.9	48	48	3900.7	342.2	363.9	2074.2	48
50	3809.7	325.9	345.6	2019.7	50	50	3903.8	342.8	364.5	2076.1	50
52	3812.9	326.5	346.2	2021.6	52	52	3907.0	343.4	365.2	2078.0	52
54	3816.0	327.0	346.8	2023.5	54	54	3910.1	343.9	365.8	2079.9	54
56	3819.2	327.6	347.4	2025.4	56	56	3913.2	344.5	366.5	2081.8	56
58	3822.3	328.1	348.1	2027.2	58	58	3916.4	345.1	367.1	2083.7	58
60	3825.5	328.7	348.7	2029.1	60	60	3919.5	345.6	367.7	2085.5	60

	40°.					41°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	3919.5	345.6	367.7	2085.5	0	0	4013.4	362.9	387.4	2142.3	0
2	3922.6	346.1	368.4	2087.4	2	2	4016.5	363.4	388.1	2144.2	2
4	3925.8	346.7	369.0	2089.3	4	4	4019.6	364.0	388.8	2146.1	4
6	3928.9	347.2	369.7	2091.2	6	6	4022.7	364.5	389.4	2148.0	6
8	3932.0	347.8	370.3	2093.1	8	8	4025.9	365.1	390.1	2149.9	8
10	3935.1	348.4	371.0	2095.0	10	10	4029.0	365.6	390.7	2151.9	10
12	3938.3	348.9	371.6	2096.9	12	12	4032.1	366.2	391.4	2153.8	12
14	3941.4	349.5	372.3	2098.8	14	14	4035.2	366.8	392.1	2155.7	14
16	3944.5	350.1	372.9	2100.7	16	16	4038.3	367.4	392.7	2157.6	16
18	3947.7	350.7	373.6	2102.6	18	18	4041.4	368.0	393.4	2159.5	18
20	3950.8	351.3	374.3	2104.5	20	20	4044.6	368.6	394.1	2161.4	20
22	3953.9	351.8	374.9	2106.3	22	22	4047.7	369.2	394.7	2163.3	22
24	3957.1	352.4	375.6	2108.2	24	24	4050.8	369.8	395.4	2165.2	24
26	3960.2	353.0	376.2	2110.1	26	26	4053.9	370.4	396.1	2167.1	26
28	3963.3	353.6	376.9	2112.0	28	28	4057.0	371.0	396.8	2169.0	28
30	3966.4	354.2	377.5	2113.9	30	30	4060.1	371.6	397.5	2170.9	30
32	3969.6	354.7	378.2	2115.8	32	32	4063.3	372.2	398.1	2172.8	32
34	3972.7	355.3	378.8	2117.7	34	34	4066.4	372.8	398.8	2174.7	34
36	3975.8	355.9	379.5	2119.6	36	36	4069.5	373.4	399.5	2176.6	36
38	3979.0	356.5	380.1	2121.5	38	38	4072.6	374.0	400.2	2178.5	38
40	3982.1	357.1	380.8	2123.4	40	40	4075.7	374.6	400.9	2180.4	40
42	3985.2	357.6	381.4	2125.3	42	42	4078.8	375.2	401.5	2182.4	42
44	3988.4	358.2	382.1	2127.2	44	44	4082.0	375.8	402.2	2184.3	44
46	3991.5	358.8	382.8	2129.1	46	46	4085.1	376.4	402.9	2186.2	46
48	3994.6	359.4	383.4	2131.0	48	48	4088.2	377.0	403.6	2188.1	48
50	3997.7	360.0	384.1	2132.9	50	50	4091.3	377.6	404.3	2190.0	50
52	4000.9	360.5	384.8	2134.7	52	52	4094.4	378.2	404.9	2191.9	52
54	4004.0	361.1	385.4	2136.6	54	54	4097.5	378.8	405.6	2193.8	54
56	4007.1	361.7	386.1	2138.5	56	56	4100.7	379.4	406.3	2195.7	56
58	4010.3	362.3	386.8	2140.4	58	58	4103.8	380.0	407.0	2197.6	58
60	4013.4	362.9	387.4	2142.3	60	60	4106.9	380.6	407.7	2199.5	60

42°.						43°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	4106.9	380.6	407.7	2199.5	0	0	4200.1	398.7	428.6	2257.1	0
2	4110.0	381.2	408.3	2201.4	2	2	4203.2	399.3	429.3	2259.0	2
4	4113.1	381.8	409.0	2203.3	4	4	4206.3	399.9	430.0	2261.0	4
6	4116.2	382.4	409.7	2205.3	6	6	4209.4	400.5	430.7	2262.9	6
8	4119.3	383.0	410.4	2207.2	8	8	4212.5	401.1	431.4	2264.8	8
10	4122.4	383.6	411.1	2209.1	10	10	4215.6	401.7	432.1	2266.7	10
12	4125.5	384.2	411.8	2211.0	12	12	4218.7	402.4	432.8	2268.7	12
14	4128.6	384.8	412.5	2212.9	14	14	4221.8	403.0	433.5	2270.6	14
16	4131.8	385.4	413.2	2214.9	16	16	4224.9	403.6	434.2	2272.5	16
18	4134.9	386.0	413.9	2216.8	18	18	4228.0	404.2	434.9	2274.5	18
20	4138.0	386.6	414.6	2218.7	20	20	4231.1	404.8	435.6	2276.4	20
22	4141.1	387.2	415.3	2220.6	22	22	4234.2	405.4	436.3	2278.3	22
24	4144.2	387.8	416.0	2222.5	24	24	4237.3	406.1	437.0	2280.2	24
26	4147.3	388.4	416.6	2224.4	26	26	4240.4	406.7	437.8	2282.2	26
28	4150.4	389.0	417.3	2226.4	28	28	4243.5	407.3	438.5	2284.1	28
30	4153.5	389.6	418.0	2228.3	30	30	4246.5	407.9	439.2	2286.0	30
32	4156.6	390.2	418.7	2230.2	32	32	4249.6	408.5	439.9	2288.0	32
34	4159.7	390.8	419.4	2232.1	34	34	4252.7	409.1	440.6	2289.9	34
36	4162.8	391.4	420.1	2234.0	36	36	4255.8	409.8	441.4	2291.8	36
38	4165.9	392.0	420.8	2236.0	38	38	4258.9	410.4	442.1	2293.8	38
40	4169.0	392.6	421.5	2237.9	40	40	4262.0	411.0	442.8	2295.7	40
42	4172.1	393.2	422.2	2239.8	42	42	4265.1	411.6	443.5	2297.7	42
44	4175.2	393.8	422.9	2241.7	44	44	4268.2	412.2	444.2	2299.6	44
46	4178.4	394.4	423.6	2243.6	46	46	4271.3	412.8	445.0	2301.5	46
48	4181.5	395.0	424.3	2245.6	48	48	4274.4	413.5	445.7	2303.5	48
50	4184.6	395.6	425.0	2247.5	50	50	4277.5	414.1	446.4	2305.4	50
52	4187.7	396.2	425.7	2249.4	52	52	4280.6	414.7	447.1	2307.3	52
54	4190.8	396.8	426.4	2251.3	54	54	4283.7	415.3	447.8	2309.3	54
56	4193.9	397.4	427.1	2253.3	56	56	4286.8	415.9	448.6	2311.2	56
58	4197.0	398.0	427.8	2255.2	58	58	4289.9	416.5	449.3	2313.1	58
60	4200.1	398.7	428.6	2257.1	60	60	4293.0	417.2	450.0	2315.1	60

MIN.	44°.					45°.					
	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	4293.0	417.2	450.0	2315.1	0	0	4385.5	436.2	472.1	2373.4	0
2	4296.1	417.8	450.7	2317.0	2	2	4388.6	436.8	472.9	2375.4	2
4	4299.2	418.4	451.5	2319.0	4	4	4391.7	437.5	473.6	2377.3	4
6	4302.2	419.1	452.2	2320.9	6	6	4394.7	438.1	474.4	2379.3	6
8	4305.3	419.7	452.9	2322.8	8	8	4397.8	438.8	475.1	2381.2	8
10	4308.4	420.3	453.7	2324.8	10	10	4400.9	439.4	475.9	2383.2	10
12	4311.5	421.0	454.4	2326.7	12	12	4404.0	440.0	476.6	2385.2	12
14	4314.6	421.6	455.1	2328.7	14	14	4407.0	440.7	477.4	2387.1	14
16	4317.7	422.2	455.9	2330.6	16	16	4410.1	441.3	478.1	2389.1	16
18	4320.7	422.9	456.6	2332.6	18	18	4413.2	442.0	478.9	2391.0	18
20	4323.8	423.5	457.3	2334.5	20	20	4416.3	442.6	479.6	2393.0	20
22	4326.9	424.1	458.1	2336.4	22	22	4419.3	443.2	480.4	2394.9	22
24	4330.0	424.8	458.8	2338.4	24	24	4422.4	443.9	481.1	2396.9	24
26	4333.1	425.4	459.5	2340.3	26	26	4425.5	444.5	481.9	2398.8	26
28	4336.2	426.0	460.3	2342.3	28	28	4428.6	445.2	482.6	2400.8	28
30	4539.2	426.7	461.0	2344.2	30	30	4431.6	445.8	483.4	2402.8	30
32	4342.3	427.3	461.7	2346.1	32	32	4434.7	446.4	484.2	2404.7	32
34	4345.4	427.9	462.5	2348.1	34	34	4437.8	447.1	484.9	2406.7	34
36	4348.5	428.6	463.2	2350.0	36	36	4440.9	447.7	485.7	2408.6	36
38	4351.6	429.2	463.9	2352.0	38	38	4444.0	448.3	486.5	2410.6	38
40	4354.7	429.8	464.7	2353.9	40	40	4447.0	448.9	487.2	2412.6	40
42	4357.7	430.5	465.4	2355.9	42	42	4450.1	449.5	488.0	2414.5	42
44	4360.8	431.1	466.2	2357.8	44	44	4453.2	450.2	488.7	2416.5	44
46	4363.9	431.7	466.9	2359.8	46	46	4456.3	450.8	489.5	2418.5	46
48	4367.0	432.4	467.7	2361.7	48	48	4459.3	451.5	490.3	2420.4	48
50	4370.1	433.0	468.4	2363.7	50	50	4462.4	452.1	491.0	2422.4	50
52	4373.2	433.6	469.1	2365.6	52	52	4465.5	452.7	491.8	2424.4	52
54	4376.2	434.3	469.9	2367.6	54	54	4468.6	453.4	492.5	2426.3	54
56	4379.3	434.9	470.6	2369.5	56	56	4471.6	454.1	493.3	2428.3	56
58	4382.4	435.6	471.4	2371.5	58	58	4474.7	454.8	494.1	2430.2	58
60	4385.5	436.2	472.1	2373.4	60	60	4477.8	455.5	494.8	2432.2	60

46°

MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	4477.8	455.5	494.8	2432.2	0
2	4480.9	456.1	495.6	2434.2	2
4	4483.9	456.8	496.5	2436.1	4
6	4487.0	457.4	497.2	2438.1	6
8	4490.0	458.1	497.9	2440.1	8
10	4493.1	458.7	498.7	2442.1	10
12	4496.2	459.4	499.5	2444.0	12
14	4499.2	460.0	500.3	2446.0	14
16	4502.3	460.7	501.0	2448.0	16
18	4505.4	461.3	501.8	2449.9	18
20	4508.4	462.0	502.6	2451.9	20
22	4511.5	462.7	503.4	2453.9	22
24	4514.6	463.3	504.1	2455.9	24
26	4517.6	464.0	504.9	2457.8	26
28	4520.7	464.6	505.7	2459.8	28
30	4523.7	465.3	506.5	2461.8	30
32	4526.8	466.0	507.3	2463.8	32
34	4529.9	466.6	508.0	2465.7	34
36	4532.9	467.3	508.8	2467.7	36
38	4536.0	467.9	509.6	2469.7	38
40	4539.1	468.6	510.4	2471.7	40
42	4542.1	469.3	511.1	2473.6	42
44	4545.2	469.9	511.9	2475.6	44
46	4548.2	470.6	512.7	2477.6	46
48	4551.3	471.2	513.5	2479.6	48
50	4554.4	471.9	514.3	2481.6	50
52	4557.4	472.6	515.1	2483.5	52
54	4560.5	473.2	515.9	2485.5	54
56	4563.6	473.9	516.7	2487.5	56
58	4566.6	474.5	517.5	2489.5	58
60	4569.7	475.2	518.3	2491.5	60

47°

MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	4569.7	475.2	518.3	2491.5	0
2	4572.7	475.9	519.0	2493.4	2
4	4575.8	476.5	519.8	2495.4	4
6	4578.8	477.2	520.6	2497.4	6
8	4581.9	477.8	521.4	2499.4	8
10	4584.9	478.5	522.2	2501.4	10
12	4588.0	479.2	523.0	2503.4	12
14	4591.0	479.8	523.8	2505.4	14
16	4594.1	480.5	524.6	2507.3	16
18	4597.1	481.1	525.4	2509.3	18
20	4600.2	481.7	526.2	2511.3	20
22	4603.2	482.3	527.0	2513.3	22
24	4606.3	483.0	527.8	2515.3	24
26	4609.3	483.7	528.6	2517.3	26
28	4612.4	484.3	529.4	2519.3	28
30	4615.4	485.0	530.2	2521.2	30
32	4618.5	485.7	531.0	2523.2	32
34	4621.5	486.3	531.8	2525.2	34
36	4624.6	487.0	532.6	2527.2	36
38	4627.6	487.7	533.4	2529.2	38
40	4630.7	488.4	534.2	2531.2	40
42	4633.7	489.1	535.0	2533.2	42
44	4636.8	489.8	535.8	2535.2	44
46	4639.8	490.5	536.6	2537.2	46
48	4642.9	491.2	537.4	2539.2	48
50	4645.9	491.9	538.2	2541.2	50
52	4649.0	492.6	539.0	2543.1	52
54	4652.0	493.3	539.8	2545.1	54
56	4655.1	494.0	540.6	2547.1	56
58	4658.1	494.7	541.4	2549.1	58
60	4661.2	495.4	542.3	2551.1	60

48°.						49°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	4661.2	495.4	542.3	2551.1	0	0	4752.3	515.9	567.0	2611.3	0
2	4664.2	496.0	543.1	2553.1	2	2	4755.3	516.5	567.8	2613.3	2
4	4667.3	496.7	543.9	2555.1	4	4	4758.4	517.2	568.7	2615.3	4
6	4670.3	497.4	544.7	2557.1	6	6	4761.4	517.9	569.5	2617.3	6
8	4673.3	498.1	545.5	2559.1	8	8	4764.4	518.6	570.3	2619.3	8
10	4676.4	498.8	546.4	2561.1	10	10	4767.4	519.3	571.2	2621.4	10
12	4679.4	499.4	547.2	2563.1	12	12	4770.5	520.0	572.0	2623.4	12
14	4682.5	500.1	548.0	2565.1	14	14	4773.5	520.7	572.8	2625.4	14
16	4685.5	500.8	548.8	2567.1	16	16	4776.5	521.4	573.7	2627.4	16
18	4688.5	501.5	549.6	2569.1	18	18	4779.6	522.1	574.5	2629.4	18
20	4691.6	502.2	550.5	2571.1	20	20	4782.6	522.8	575.3	2631.4	20
22	4694.6	502.8	551.3	2573.1	22	22	4785.6	523.5	576.2	2633.5	22
24	4697.6	503.5	552.1	2575.1	24	24	4788.7	524.2	577.0	2635.5	24
26	4700.7	504.2	552.9	2577.1	26	26	4791.7	524.9	577.9	2637.5	26
28	4703.7	504.9	553.7	2579.1	28	28	4794.7	525.6	578.7	2639.5	28
30	4706.7	505.6	554.6	2581.1	30	30	4797.7	526.3	579.6	2641.5	30
32	4709.8	506.2	555.4	2583.1	32	32	4800.8	527.0	580.4	2643.5	32
34	4712.8	506.9	556.2	2585.1	34	34	4803.8	527.7	581.3	2645.6	34
36	4715.9	507.6	557.0	2587.2	36	36	4806.8	528.4	582.1	2647.6	36
38	4718.9	508.3	557.8	2589.2	38	38	4809.9	529.1	583.0	2649.6	38
40	4721.9	509.0	558.7	2591.2	40	40	4812.9	529.8	583.8	2651.6	40
42	4725.0	509.6	559.5	2593.2	42	42	4815.9	530.5	584.7	2653.7	42
44	4728.0	510.3	560.3	2595.2	44	44	4819.0	531.2	585.5	2655.7	44
46	4731.0	511.0	561.2	2597.2	46	46	4822.0	531.9	586.4	2657.7	46
48	4734.1	511.7	562.0	2599.2	48	48	4825.0	532.6	587.2	2659.7	48
50	4737.1	512.4	562.8	2601.2	50	50	4828.0	533.3	588.1	2661.8	50
52	4740.2	513.1	563.7	2603.2	52	52	4831.1	534.0	588.9	2663.8	52
54	4743.2	513.8	564.5	2605.2	54	54	4834.1	534.7	589.8	2665.8	54
56	4746.2	514.5	565.3	2607.2	56	56	4837.1	535.4	590.6	2667.8	56
58	4749.3	515.2	566.2	2609.3	58	58	4840.2	536.1	591.5	2669.9	58
60	4752.3	515.9	567.0	2611.3	60	60	4843.2	536.8	592.4	2671.9	60

	50°.					51°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	4843.2	536.8	592.4	2671.9	0	0	4933.6	558.2	618.5	2733.0	0
2	4846.2	537.5	593.2	2673.9	2	2	4936.6	558.9	619.3	2735.1	2
4	4849.2	538.2	594.1	2676.0	4	4	4939.6	559.7	620.2	2737.1	4
6	4852.2	538.9	594.9	2678.0	6	6	4942.6	560.4	621.1	2739.2	6
8	4855.2	539.6	595.8	2680.0	8	8	4945.6	561.1	622.0	2741.2	8
10	4858.3	540.3	596.7	2682.1	10	10	4948.6	561.8	622.9	2743.3	10
12	4861.3	541.0	597.5	2684.1	12	12	4951.6	562.5	623.7	2745.3	12
14	4864.3	541.7	598.4	2686.1	14	14	4954.6	563.3	624.6	2747.4	14
16	4867.3	542.4	599.3	2688.2	16	16	4957.6	564.0	625.5	2749.4	16
18	4870.3	543.1	600.1	2690.2	18	18	4960.6	564.7	626.4	2751.5	18
20	4873.3	543.9	601.0	2692.3	20	20	4963.6	565.4	627.3	2753.5	20
22	4876.3	544.6	601.9	2694.3	22	22	4966.6	566.2	628.2	2755.6	22
24	4879.4	545.3	602.7	2696.3	24	24	4969.6	566.9	629.9	2757.7	24
26	4882.4	546.0	603.6	2698.4	26	26	4972.6	567.6	630.0	2759.7	26
28	4885.4	546.7	604.5	2700.4	28	28	4975.6	568.3	630.9	2761.8	28
30	4888.4	547.4	605.3	2702.4	30	30	4978.6	569.1	631.8	2763.8	30
32	4891.4	548.1	606.2	2704.5	32	32	4981.6	569.8	632.7	2765.9	32
34	4894.4	548.8	607.0	2706.5	34	34	4984.6	570.5	633.6	2767.9	34
36	4897.4	549.5	607.9	2708.6	36	36	4987.7	571.2	634.5	2770.0	36
38	4900.4	550.2	608.8	2710.6	38	38	4990.7	572.0	635.3	2772.0	38
40	4903.5	551.0	609.7	2712.6	40	40	4993.7	572.7	636.2	2774.1	40
42	4906.5	551.7	610.5	2714.7	42	42	4996.7	573.4	637.1	2776.2	42
44	4909.5	552.4	611.4	2716.7	44	44	4999.7	574.1	638.0	2778.2	44
46	4912.5	553.1	612.3	2718.8	46	46	5002.7	574.9	638.9	2780.3	46
48	4915.5	553.8	613.2	2720.8	48	48	5005.7	575.6	639.8	2782.3	48
50	4918.5	554.5	614.1	2722.8	50	50	5008.7	576.3	640.7	2784.4	50
52	4921.5	555.2	614.9	2724.9	52	52	5011.7	577.0	641.6	2786.4	52
54	4924.6	555.9	615.8	2726.9	54	54	5014.7	577.8	642.5	2788.5	54
56	4927.6	556.6	616.7	2729.0	56	56	5017.7	578.5	643.4	2790.6	56
58	4930.6	557.4	617.6	2731.0	58	58	5020.7	579.2	644.3	2792.6	58
60	4933.6	558.2	618.5	2733.0	60	60	5023.7	579.9	645.2	2794.7	60

52°.						53°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	5023.7	579.9	645.2	2794.7	0	0	5113.5	602.0	672.7	2856.9	0
2	5026.7	580.6	646.1	2796.8	2	2	5116.5	602.8	673.7	2858.9	2
4	5029.7	581.3	647.0	2798.8	4	4	5119.4	603.5	674.6	2861.0	4
6	5032.7	582.1	647.9	2800.9	6	6	5122.4	604.3	675.5	2863.1	6
8	5035.7	582.8	648.9	2803.0	8	8	5125.4	605.0	676.4	2865.2	8
10	5038.7	583.5	649.8	2805.0	10	10	5128.4	605.8	677.4	2867.3	10
12	5041.7	584.3	650.7	2807.1	12	12	5131.3	606.5	678.3	2869.4	12
14	5044.7	585.0	651.6	2809.2	14	14	5134.3	607.3	679.2	2871.5	14
16	5047.7	585.7	652.5	2811.2	16	16	5137.3	608.0	680.2	2873.5	16
18	5050.7	586.5	653.4	2813.3	18	18	5140.3	608.8	681.1	2875.6	18
20	5053.6	587.2	654.3	2815.4	20	20	5143.2	609.5	682.0	2877.7	20
22	5056.6	587.9	655.2	2817.4	22	22	5146.2	610.3	683.0	2879.8	22
24	5059.6	588.7	656.2	2819.5	24	24	5149.2	611.0	683.9	2881.9	24
26	5062.6	589.4	657.1	2821.6	26	26	5152.1	611.8	684.9	2884.0	26
28	5065.6	590.1	658.0	2823.6	28	28	5155.1	612.5	685.8	2886.1	28
30	5068.6	590.9	658.9	2825.7	30	30	5158.1	613.3	686.7	2888.1	30
32	5071.6	591.6	659.8	2827.8	32	32	5161.1	614.0	687.7	2890.2	32
34	5074.6	592.3	660.7	2829.8	34	34	5164.0	614.8	688.6	2892.3	34
36	5077.6	593.1	661.6	2831.9	36	36	5167.0	615.5	689.6	2894.4	36
38	5080.6	593.8	662.5	2834.0	38	38	5170.0	616.3	690.5	2896.5	38
40	5083.6	594.5	663.5	2836.1	40	40	5173.0	617.0	691.5	2898.6	40
42	5086.6	595.3	664.4	2838.2	42	42	5175.9	617.8	692.4	2900.7	42
44	5089.6	596.0	665.3	2840.2	44	44	5178.9	618.5	693.4	2902.8	44
46	5092.6	596.7	666.2	2842.3	46	46	5181.9	619.3	694.3	2904.9	46
48	5095.6	597.5	667.2	2844.4	48	48	5184.9	620.1	695.3	2907.0	48
50	5098.6	598.2	668.1	2846.5	50	50	5187.8	620.8	696.2	2909.1	50
52	5101.6	598.9	669.0	2848.5	52	52	5190.8	621.5	697.1	2911.2	52
54	5104.6	599.7	669.9	2850.6	54	54	5193.8	622.3	698.1	2913.3	54
56	5107.6	600.4	670.9	2852.7	56	56	5196.7	623.0	699.0	2915.4	56
58	5110.6	601.2	671.8	2854.8	58	58	5199.7	623.8	700.0	2917.5	58
60	5113.5	602.0	672.7	2856.9	60	60	5202.7	624.6	700.9	2919.5	60

54°.						55°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	5202.7	624.6	700.9	2919.5	0	0	5291.7	647.4	729.9	2982.8	0
2	5205.7	625.4	701.9	2921.6	2	2	5294.6	648.1	730.9	2984.9	2
4	5208.6	626.1	702.8	2923.8	4	4	5297.6	648.9	731.9	2987.1	4
6	5211.6	626.9	703.8	2925.9	6	6	5300.5	649.6	732.9	2989.2	6
8	5214.6	627.6	704.8	2928.0	8	8	5303.5	650.4	733.8	2991.3	8
10	5217.5	628.4	705.7	2930.1	10	10	5306.4	651.2	734.8	2993.4	10
12	5220.5	629.2	706.7	2932.2	12	12	5309.4	652.0	735.8	2995.5	12
14	5223.5	629.9	707.7	2934.3	14	14	5312.3	652.7	736.8	2997.7	14
16	5226.4	630.7	708.6	2936.4	16	16	5315.3	653.5	737.8	2999.8	16
18	5229.4	631.4	709.6	2938.5	18	18	5318.2	654.3	738.7	3001.9	18
20	5232.4	632.2	710.5	2940.6	20	20	5321.2	655.1	739.7	3004.0	20
22	5235.3	633.0	711.5	2942.7	22	22	5324.1	655.8	740.7	3006.2	22
24	5238.3	633.7	712.5	2944.8	24	24	5327.1	656.6	741.7	3008.3	24
26	5241.3	634.5	713.4	2946.9	26	26	5330.0	657.4	742.7	3010.4	26
28	5244.2	635.2	714.4	2949.0	28	28	5333.0	658.2	743.7	3012.5	28
30	5247.2	636.0	715.3	2951.1	30	30	5335.9	658.9	744.7	3014.7	30
32	5250.2	636.8	716.3	2953.2	32	32	5338.8	659.7	745.7	3016.8	32
34	5253.1	637.5	717.3	2955.3	34	34	5341.8	660.5	746.7	3018.9	34
36	5256.1	638.3	718.2	2957.5	36	36	5344.7	661.3	747.7	3021.1	36
38	5259.1	639.0	719.2	2959.6	38	38	5347.7	662.0	748.7	3023.2	38
40	5262.0	639.8	720.2	2961.7	40	40	5350.6	662.8	749.7	3025.3	40
42	5265.0	640.6	721.1	2963.8	42	42	5353.6	663.6	750.7	3027.5	42
44	5268.0	641.3	722.1	2965.9	44	44	5356.5	664.4	751.7	3029.6	44
46	5270.9	642.1	723.1	2968.0	46	46	5359.5	665.1	752.6	3031.7	46
48	5273.9	642.8	724.1	2970.1	48	48	5362.4	665.9	753.6	3033.8	48
50	5276.9	643.6	725.0	2972.2	50	50	5365.4	666.7	754.6	3036.0	50
52	5279.8	644.4	726.0	2974.4	52	52	5368.3	667.5	755.6	3038.1	52
54	5282.8	645.1	727.0	2976.5	54	54	5371.3	668.3	756.6	3040.2	54
56	5285.8	645.9	728.0	2978.6	56	56	5374.2	669.1	757.6	3042.4	56
58	5288.7	646.6	729.0	2980.7	58	58	5377.2	669.9	758.6	3044.5	58
60	5291.7	647.4	729.9	2982.8	60	60	5380.1	670.7	759.6	3046.6	60

	56°.					57°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	5380.1	670.7	759.6	3046.6	0	0	5468.2	694.4	790.2	3111.1	0
2	5383.0	671.4	760.6	3048.8	2	2	5471.1	695.2	791.2	3113.3	2
4	5386.0	672.2	761.6	3050.9	4	4	5474.0	696.0	792.2	3115.4	4
6	5388.9	672.9	762.7	3053.1	6	6	5477.0	696.8	793.3	3117.6	6
8	5391.8	673.7	763.7	3055.2	8	8	5479.9	697.6	794.3	3119.7	8
10	5394.8	674.4	764.7	3057.4	10	10	5482.8	698.4	795.3	3121.9	10
12	5397.7	675.2	765.7	3059.5	12	12	5485.7	699.2	796.3	3124.1	12
14	5400.7	676.0	766.7	3061.6	14	14	5488.7	700.0	797.4	3126.2	14
16	5403.6	676.8	767.7	3063.8	16	16	5491.6	700.8	798.4	3128.4	16
18	5406.5	677.6	768.7	3065.9	18	18	5494.5	701.6	799.4	3130.6	18
20	5409.5	678.4	769.7	3068.1	20	20	5497.4	702.4	800.5	3132.7	20
22	5412.4	679.2	770.8	3070.2	22	22	5500.3	703.2	801.5	3134.9	22
24	5415.3	680.0	771.8	3072.4	24	24	5503.3	704.0	802.6	3137.0	24
26	5418.3	680.8	772.8	3074.5	26	26	5506.2	704.8	803.6	3139.2	26
28	5421.2	681.6	773.8	3076.6	28	28	5509.1	705.6	804.7	3141.4	28
30	5424.1	682.4	774.8	3078.8	30	30	5512.0	706.4	805.7	3143.5	30
32	5427.1	683.2	775.8	3080.9	32	32	5515.0	707.2	806.8	3145.7	32
34	5430.0	684.0	776.8	3083.1	34	34	5517.9	708.0	807.8	3147.9	34
36	5433.0	684.8	777.8	3085.2	36	36	5520.8	708.8	808.8	3150.0	36
38	5435.9	685.6	778.9	3087.4	38	38	5523.7	709.6	809.9	3152.2	38
40	5438.8	686.4	779.9	3089.6	40	40	5526.7	710.4	810.9	3154.4	40
42	5441.8	687.2	780.9	3091.7	42	42	5529.6	711.2	812.0	3156.6	42
44	5444.7	688.0	781.9	3093.9	44	44	5532.5	712.0	813.0	3158.7	44
46	5447.6	688.8	783.0	3096.0	46	46	5535.4	712.8	814.1	3160.9	46
48	5450.6	689.6	784.0	3098.2	48	48	5538.4	713.6	815.1	3163.1	48
50	5453.5	690.4	785.0	3100.3	50	50	5541.3	714.4	816.2	3165.3	50
52	5456.5	691.2	786.0	3102.5	52	52	5544.2	715.2	817.2	3167.4	52
54	5459.4	692.0	787.1	3104.6	54	54	5547.1	716.0	818.3	3169.6	54
56	5462.3	692.8	788.1	3106.8	56	56	5550.0	716.8	819.3	3171.8	56
58	5465.3	693.6	789.1	3108.9	58	58	5553.0	717.6	820.4	3174.0	58
60	5468.2	694.4	790.2	3111.1	60	60	5555.9	718.4	821.4	3176.1	60

	58°.						59°.				
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	5555.9	718.4	821.4	3176.1	0	0	5643.1	742.8	853.5	3241.9	0
2	5558.8	719.2	822.5	3178.3	2	2	5646.0	743.6	854.6	3244.1	2
4	5561.7	720.0	823.5	3180.5	4	4	5648.9	744.4	855.7	3246.3	4
6	5564.6	720.8	824.6	3182.7	6	6	5651.8	745.3	856.8	3248.5	6
8	5567.5	721.6	825.7	3184.9	8	8	5654.7	746.1	857.9	3250.7	8
10	5570.4	722.4	826.7	3187.1	10	10	5657.6	746.9	859.0	3252.9	10
12	5573.3	723.2	827.8	3189.2	12	12	5660.5	747.7	860.0	3255.1	12
14	5576.2	724.0	828.9	3191.4	14	14	5663.4	748.6	861.1	3257.3	14
16	5579.2	724.8	829.9	3193.6	16	16	5666.3	749.4	862.2	3259.5	16
18	5582.1	725.6	831.0	3195.8	18	18	5669.2	750.2	863.3	3261.7	18
20	5585.0	726.5	832.1	3198.0	20	20	5672.1	751.1	864.4	3263.9	20
22	5587.9	727.3	833.1	3200.2	22	22	5675.0	751.9	865.5	3266.1	22
24	5590.8	728.1	834.2	3202.4	24	24	5677.9	752.7	866.6	3268.3	24
26	5593.7	728.9	835.3	3204.5	26	26	5680.8	753.5	867.7	3270.5	26
28	5596.6	729.7	836.3	3206.7	28	28	5683.7	754.4	868.8	3272.7	28
30	5599.5	730.5	837.4	3208.9	30	30	5686.5	755.2	869.9	3274.9	30
32	5602.4	731.3	838.4	3211.1	32	32	5689.4	756.0	871.0	3277.1	32
34	5605.3	732.1	839.5	3213.3	34	34	5692.3	756.9	872.1	3279.4	34
36	5608.2	732.9	840.6	3215.5	36	36	5695.2	757.7	873.2	3281.6	36
38	5611.1	733.7	841.6	3217.7	38	38	5698.1	758.5	874.3	3283.8	38
40	5614.0	734.6	842.7	3219.9	40	40	5701.0	759.4	875.4	3286.0	40
42	5616.9	735.4	843.8	3222.1	42	42	5703.9	760.2	876.5	3288.2	42
44	5619.8	736.2	844.9	3224.3	44	44	5706.8	761.0	877.6	3290.5	44
46	5622.8	737.0	846.0	3226.5	46	46	5709.7	761.9	878.7	3292.7	46
48	5625.7	737.8	847.0	3228.7	48	48	5712.6	762.7	879.8	3294.9	48
50	5628.6	738.6	848.1	3230.9	50	50	5715.5	763.5	880.9	3297.1	50
52	5631.5	739.4	849.2	3233.1	52	52	5718.4	764.4	882.0	3299.3	52
54	5634.4	740.2	850.3	3235.3	54	54	5721.3	765.2	883.1	3301.5	54
56	5637.3	741.0	851.4	3237.5	56	56	5724.2	766.0	884.2	3303.8	56
58	5640.2	741.9	852.5	3239.7	58	58	5727.1	766.8	885.3	3306.0	58
60	5643.1	742.8	853.5	3241.9	60	60	5730.0	767.7	886.4	3308.2	60

60°.						61°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	5730.0	767.7	886.4	3308.2	0	0	5816.4	792.9	920.2	3375.2	0
2	5732.9	768.5	887.5	3310.4	2	2	5819.3	793.7	921.4	3377.4	2
4	5735.8	769.4	888.7	3312.7	4	4	5822.1	794.6	922.5	3379.7	4
6	5738.6	770.2	889.8	3314.9	6	6	5825.0	795.4	923.6	3381.9	6
8	5741.5	771.1	890.9	3317.1	8	8	5827.9	796.3	924.8	3384.2	8
10	5744.4	771.9	892.0	3319.3	10	10	5830.7	797.1	925.9	3386.4	10
12	5747.3	772.7	893.1	3321.6	12	12	5833.6	798.0	927.1	3388.7	12
14	5750.2	773.6	894.3	3323.8	14	14	5836.5	798.8	928.2	3390.9	14
16	5753.0	774.4	895.4	3326.0	16	16	5839.3	799.7	929.3	3393.2	16
18	5755.9	775.3	896.5	3328.3	18	18	5842.2	800.5	930.5	3395.4	18
20	5758.8	776.1	897.6	3330.5	20	20	5845.1	801.4	931.6	3397.7	20
22	5761.7	776.9	898.8	3332.7	22	22	5847.9	802.2	932.8	3399.9	22
24	5764.6	777.8	899.9	3334.9	24	24	5850.8	803.1	933.9	3402.2	24
26	5767.4	778.6	901.0	3337.2	26	26	5853.7	803.9	935.1	3404.4	26
28	5770.3	779.5	902.1	3339.4	28	28	5856.5	804.8	936.3	3406.7	28
30	5773.2	780.3	903.2	3341.6	30	30	5859.4	805.6	937.4	3408.9	30
32	5776.1	781.1	904.4	3343.9	32	32	5862.3	806.5	938.6	3411.2	32
34	5779.0	782.0	905.5	3346.1	34	34	5865.1	807.3	939.7	3413.5	34
36	5781.8	782.8	906.6	3348.3	36	36	5868.0	808.2	940.9	3415.7	36
38	5784.7	783.7	907.7	3350.6	38	38	5870.9	809.0	942.1	3418.0	38
40	5787.6	784.5	908.8	3352.8	40	40	5873.7	809.9	943.2	3420.3	40
42	5790.5	785.3	910.0	3355.0	42	42	5876.6	810.7	944.4	3422.5	42
44	5793.4	786.2	911.1	3357.3	44	44	5879.5	811.6	945.5	3424.8	44
46	5796.2	787.0	912.3	3359.5	46	46	5882.3	812.4	946.7	3427.1	46
48	5799.1	787.9	913.4	3361.8	48	48	5885.2	813.3	947.8	3429.3	48
50	5802.0	788.7	914.5	3364.0	50	50	5888.1	814.1	949.0	3431.6	50
52	5804.9	789.5	915.7	3366.2	52	52	5890.9	815.0	950.2	3433.9	52
54	5807.8	790.4	916.8	3368.5	54	54	5893.8	815.8	951.3	3436.1	54
56	5810.6	791.2	918.0	3370.7	56	56	5896.7	816.7	952.5	3438.4	56
58	5813.5	792.1	919.1	3373.0	58	58	5899.5	817.5	953.6	3440.7	58
60	5816.4	792.9	920.2	3375.2	60	60	5902.4	818.4	954.8	3442.9	60

62°.						63°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD	EX. SEC.	A. D.	MIN.
0	5902.4	818.4	954.8	3442.9	0	0	5987.8	844.4	990.3	3511.3	0
2	5905.2	819.3	956.0	3445.2	2	2	5990.6	845.3	991.5	3513.6	2
4	5908.1	820.1	957.2	3447.5	4	4	5993.5	846.2	992.7	3515.9	4
	5910.9	821.0	958.3	3449.7	6	6	5996.3	847.1	993.9	3518.2	6
	5913.8	821.8	959.5	3452.0	8	8	5999.1	847.9	995.1	3520.5	8
	5916.6	822.7	960.7	3454.3	10	10	6002.0	848.8	996.3	3522.8	10
	5919.5	823.6	961.9	3456.6	12	12	6004.8	849.7	997.5	3525.1	12
	5922.3	824.4	963.0	3458.8	14	14	6007.7	850.6	998.7	3527.4	14
	5925.2	825.3	964.2	3461.1	16	16	6010.5	851.4	999.9	3529.7	16
18	5928.0	826.1	965.4	3463.4	18	18	6013.3	852.3	1001.1	3532.0	18
20	5930.9	827.0	966.6	3465.7	20	20	6016.2	853.2	1002.3	3534.3	20
22	5933.7	827.9	967.8	3467.9	22	22	6019.0	854.1	1003.5	3536.6	22
24	5936.6	828.7	968.9	3470.2	24	24	6021.8	854.9	1004.7	3538.9	24
26	5939.4	829.6	970.1	3472.5	26	26	6024.7	855.8	1005.9	3541.2	26
28	5942.3	830.4	971.3	3474.7	28	28	6027.5	856.7	1007.1	3543.5	28
30	5945.1	831.3	972.5	3477.0	30	30	6030.3	857.6	1008.4	3545.8	30
32	5947.9	832.2	973.6	3479.3	32	32	6033.2	858.4	1009.6	3548.1	32
34	5950.8	833.0	974.8	3481.6	34	34	6036.0	859.3	1010.8	3550.4	34
36	5953.6	833.9	976.0	3483.9	36	36	6038.9	860.2	1012.0	3552.7	36
38	5956.5	834.7	977.2	3486.2	38	38	6041.7	861.1	1013.2	3555.0	38
40	5959.3	835.6	978.4	3488.5	40	40	6044.5	861.9	1014.5	3557.3	40
42	5962.2	836.5	979.6	3490.7	42	42	6047.4	862.8	1015.7	3559.6	42
44	5965.0	837.4	980.8	3493.0	44	44	6050.2	863.7	1016.9	3562.0	44
46	5967.9	838.3	982.0	3495.3	46	46	6053.0	864.6	1018.1	3564.3	46
48	5970.7	839.1	983.2	3497.6	48	48	6055.9	865.4	1019.3	3566.6	48
50	5973.6	840.0	984.4	3499.9	50	50	6058.7	866.3	1020.6	3568.9	50
52	5976.4	840.9	985.5	3502.2	52	52	6061.6	867.2	1021.8	3571.2	52
54	5979.3	841.7	986.7	3504.5	54	54	6064.4	868.1	1023.0	3573.5	54
46	5982.1	842.6	987.9	3506.8	56	56	6067.2	868.9	1024.2	3575.8	56
	5985.0	843.5	989.1	3509.0	58	58	6070.1	869.8	1025.4	3578.1	58
	5987.8	844.4	990.3	3511.3	60	60	6072.9	870.7	1026.7	3580.4	60

64°.						65°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	6072.9	870.7	1026.7	3580.4	0	0	6157.5	897.3	1064.0	3650.4	0
2	6075.7	871.5	1027.9	3582.8	2	2	6160.3	898.2	1065.2	3652.8	2
4	6078.5	872.4	1029.2	3585.1	4	4	6163.1	899.1	1066.5	3655.1	4
6	6081.4	873.3	1030.4	3587.4	6	6	6165.9	900.0	1067.7	3657.5	6
8	6084.2	874.2	1031.7	3589.7	8	8	6168.7	900.9	1069.0	3659.8	8
10	6087.0	875.1	1032.9	3592.1	10	10	6171.5	901.8	1070.2	3662.2	10
12	6089.8	875.9	1034.1	3594.4	12	12	6174.3	902.7	1071.5	3664.5	12
14	6092.6	876.8	1035.4	3596.7	14	14	6177.1	903.6	1072.7	3666.9	14
16	6095.5	877.7	1036.6	3599.1	16	16	6179.9	904.5	1074.0	3669.2	16
18	6098.3	878.6	1037.9	3601.4	18	18	6182.7	905.4	1075.2	3671.6	18
20	6101.1	879.5	1039.1	3603.7	20	20	6185.5	906.3	1076.6	3673.9	20
22	6103.9	880.3	1040.3	3606.0	22	22	6188.3	907.2	1077.8	3676.2	22
24	6106.7	881.2	1041.6	3608.4	24	24	6191.1	908.1	1079.1	3678.6	24
26	6109.6	882.1	1042.8	3610.7	26	26	6193.9	909.0	1080.4	3680.9	26
28	6112.4	883.0	1044.1	3613.0	28	28	6196.7	909.9	1081.7	3683.3	28
30	6115.2	883.9	1045.3	3615.3	30	30	6199.5	910.8	1083.0	3685.6	30
32	6118.0	884.7	1046.5	3617.7	32	32	6202.3	911.7	1084.2	3688.0	32
34	6120.8	885.6	1047.8	3620.0	34	34	6205.1	912.6	1085.5	3690.4	34
36	6123.7	886.5	1049.0	3622.3	36	36	6208.0	913.5	1086.8	3692.7	36
38	6126.5	887.4	1050.3	3624.7	38	38	6210.8	914.4	1088.1	3695.1	38
40	6129.3	888.3	1051.5	3627.0	40	40	6213.6	915.3	1089.4	3697.4	40
42	6132.1	889.2	1052.7	3629.4	42	42	6216.4	916.2	1090.6	3699.8	42
44	6134.9	890.1	1054.0	3631.7	44	44	6219.2	917.1	1091.9	3702.2	44
46	6137.8	891.0	1055.2	3634.0	46	46	6222.0	918.0	1093.2	3704.5	46
48	6140.6	891.9	1056.5	3636.4	48	48	6224.8	918.9	1094.5	3706.9	48
50	6143.4	892.8	1057.7	3638.7	50	50	6227.6	919.8	1095.8	3709.3	50
52	6146.2	893.7	1059.0	3641.1	52	52	6230.4	920.7	1097.0	3711.6	52
54	6149.0	894.6	1060.2	3643.4	54	54	6233.2	921.6	1098.3	3714.0	54
56	6151.9	895.5	1061.5	3645.7	56	56	6236.0	922.5	1099.6	3716.3	56
58	6154.7	896.4	1062.7	3648.1	58	58	6238.8	923.4	1100.9	3718.7	58
60	6157.5	897.3	1064.0	3650.4	60	60	6241.6	924.3	1102.2	3721.1	60

66°.						67°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	6241.6	924.3	1102.2	3721.1	0	0	6325.2	951.8	1141.5	3792.6	0
2	6244.4	925.2	1103.5	3723.4	2	2	6328.0	952.7	1142.8	3795.0	2
4	6247.2	926.1	1104.8	3725.8	4	4	6330.7	953.6	1144.1	3797.4	4
6	6250.0	927.0	1106.1	3728.2	6	6	6333.5	954.5	1145.4	3799.8	6
8	6252.7	927.9	1107.4	3730.6	8	8	6336.3	955.5	1146.7	3802.2	8
10	6255.5	928.8	1108.7	3732.9	10	10	6339.0	956.4	1148.1	3804.6	10
12	6258.3	929.8	1110.0	3735.3	12	12	6341.8	957.3	1149.4	3807.0	12
14	6261.1	930.7	1111.3	3737.7	14	14	6344.6	958.2	1150.7	3809.4	14
16	6263.9	931.6	1112.6	3740.1	16	16	6347.4	959.2	1152.0	3811.8	16
18	6266.7	932.5	1113.9	3742.4	18	18	6350.1	960.1	1153.3	3814.2	18
20	6269.5	933.4	1115.2	3744.8	20	20	6352.9	961.0	1154.7	3816.6	20
22	6272.3	934.3	1116.5	3747.2	22	22	6355.7	961.9	1156.0	3819.0	22
24	6275.0	935.3	1117.8	3749.6	24	24	6358.4	962.9	1157.4	3821.4	24
26	6277.8	936.2	1119.1	3751.9	26	26	6361.2	963.8	1158.7	3823.8	26
28	6280.6	937.1	1120.4	3754.3	28	28	6364.0	964.7	1160.1	3826.2	28
30	6283.4	938.0	1121.7	3756.7	30	30	6366.7	965.6	1161.4	3828.6	30
32	6286.2	938.9	1123.0	3759.1	32	32	6369.5	966.6	1162.8	3831.0	32
34	6289.0	939.8	1124.3	3761.5	34	34	6372.3	967.5	1164.1	3833.4	34
36	6291.8	940.8	1125.6	3763.9	36	36	6375.1	968.4	1165.5	3835.9	36
38	6294.5	941.7	1126.9	3766.3	38	38	6377.8	969.3	1166.8	3838.3	38
40	6297.3	942.6	1128.3	3768.7	40	40	6380.6	970.3	1168.2	3840.7	40
42	6300.1	943.5	1129.6	3771.0	42	42	6383.4	971.2	1169.5	3843.1	42
44	6302.9	944.4	1130.9	3773.4	44	44	6386.1	972.1	1170.9	3845.5	44
46	6305.7	945.3	1132.2	3775.8	46	46	6388.9	973.0	1172.2	3847.9	46
48	6308.5	946.3	1133.5	3778.2	48	48	6391.7	974.0	1173.6	3850.4	48
50	6311.3	947.2	1134.9	3780.6	50	50	6394.4	974.9	1174.9	3852.8	50
52	6314.1	948.1	1136.2	3783.0	52	52	6397.2	975.8	1176.3	3855.2	52
54	6316.8	949.0	1137.5	3785.4	54	54	6400.0	976.8	1177.6	3857.6	54
	6319.6	949.9	1138.8	3787.8	56	56	6402.8	977.7	1179.0	3860.0	56
	6322.4	950.8	1140.1	3790.2	58	58	6405.5	978.6	1180.3	3862.5	58
	6325.2	951.8	1141.5	3792.6	60	60	6408.3	979.6	1181.6	3864.9	60

68°.						69°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	6408.3	979.6	1181.6	3864.9	0	0	6491.1	1007.7	1222.9	3938.1	0
2	6411.1	980.5	1183.0	3867.3	2	2	6493.8	1008.7	1224.3	3940.6	2
4	6413.8	981.4	1184.4	3869.7	4	4	6496.6	1009.6	1225.7	3943.0	4
6	6416.6	982.4	1185.7	3872.2	6	6	6499.3	1010.6	1227.1	3945.5	6
8	6419.3	983.3	1187.1	3874.6	8	8	6502.1	1011.5	1228.5	3947.9	8
10	6422.1	984.2	1188.5	3877.0	10	10	6504.8	1012.5	1229.9	3950.4	10
12	6424.9	985.2	1189.8	3879.5	12	12	6507.5	1013.4	1231.3	3952.9	12
14	6427.6	986.1	1191.2	3881.9	14	14	6510.3	1014.4	1232.7	3955.3	14
16	6430.4	987.0	1192.6	3884.3	16	16	6513.0	1015.3	1234.1	3957.8	16
18	6433.1	988.0	1193.9	3886.8	18	18	6515.8	1016.3	1235.5	3960.2	18
20	6435.9	988.9	1195.3	3889.2	20	20	6518.5	1017.2	1236.9	3962.7	20
22	6438.7	989.8	1196.7	3891.6	22	22	6521.2	1018.2	1238.3	3965.2	22
24	6441.4	990.8	1198.0	3894.1	24	24	6524.0	1019.1	1239.7	3967.6	24
26	6444.2	991.7	1199.4	3896.5	26	26	6526.7	1020.1	1241.1	3970.1	26
28	6446.9	992.6	1200.8	3898.9	28	28	6529.5	1021.0	1242.5	3972.5	28
30	6449.7	993.6	1202.1	3901.4	30	30	6532.2	1022.0	1243.9	3975.0	30
32	6452.5	994.5	1203.5	3903.8	32	32	6534.9	1022.9	1245.3	3977.5	32
34	6455.2	995.4	1204.9	3906.3	34	34	6537.7	1023.9	1246.7	3980.0	34
36	6458.0	996.4	1206.2	3908.7	36	36	6540.4	1024.8	1248.1	3982.4	36
38	6460.7	997.3	1207.6	3911.2	38	38	6543.2	1025.8	1249.5	3984.9	38
40	6463.5	998.2	1209.0	3913.6	40	40	6545.9	1026.7	1250.9	3987.4	40
42	6466.3	999.2	1210.3	3916.1	42	42	6548.6	1027.7	1252.3	3989.9	42
44	6469.0	1000.1	1211.7	3918.5	44	44	6551.4	1028.6	1253.7	3992.3	44
46	6471.8	1001.0	1213.1	3921.0	46	46	6554.1	1029.6	1255.1	3994.8	46
48	6474.5	1002.0	1214.5	3923.4	48	48	6556.9	1030.5	1256.5	3997.3	48
50	6477.3	1002.9	1215.9	3925.9	50	50	6559.6	1031.5	1257.9	3999.8	50
52	6480.1	1003.8	1217.3	3928.3	52	52	6562.3	1032.4	1259.3	4002.2	52
54	6482.8	1004.8	1218.7	3930.8	54	54	6565.1	1033.4	1260.7	4004.7	54
56	6485.6	1005.7	1220.1	3933.2	56	56	6567.8	1034.3	1262.1	4007.2	56
58	6488.3	1006.7	1221.5	3935.7	58	58	6570.6	1035.3	1263.5	4009.7	58
60	6491.1	1007.7	1222.9	3938.1	60	60	6573.3	1036.3	1265.0	4012.1	60

	70°.					71°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	6573.3	1036.3	1265.0	4012.1	0	0	6654.9	1065.1	1308.4	4087.1	0
2	6576.0	1037.3	1266.4	4014.6	2	2	6657.6	1066.1	1309.9	4089.7	2
4	6578.7	1038.2	1267.9	4017.1	4	4	6660.3	1067.0	1311.3	4092.2	4
6	6581.5	1039.2	1269.3	4019.6	6	6	6663.0	1068.0	1312.8	4094.7	6
8	6584.2	1040.1	1270.8	4022.1	8	8	6665.7	1068.9	1314.2	4097.2	8
10	6586.9	1041.1	1272.2	4024.6	10	10	6668.4	1069.9	1315.7	4099.8	10
12	6589.6	1042.1	1273.6	4027.1	12	12	6671.1	1070.9	1317.2	4102.3	12
14	6592.3	1043.0	1275.1	4029.6	14	14	6673.8	1071.9	1318.6	4104.8	14
16	6595.1	1044.0	1276.5	4032.1	16	16	6676.6	1072.9	1320.1	4107.3	16
18	6597.8	1044.9	1278.0	4034.6	18	18	6679.3	1073.8	1321.5	4109.8	18
20	6600.5	1045.9	1279.4	4037.1	20	20	6682.0	1074.8	1323.0	4112.4	20
22	6603.2	1046.9	1280.8	4039.6	22	22	6684.7	1075.8	1324.4	4114.9	22
24	6605.9	1047.8	1282.3	4042.1	24	24	6687.4	1076.8	1325.9	4117.4	24
26	6608.7	1048.8	1283.7	4044.6	26	26	6690.1	1077.7	1327.4	4119.9	26
28	6611.4	1049.7	1285.2	4047.1	28	28	6692.8	1078.7	1328.9	4122.4	28
30	6614.1	1050.7	1286.6	4049.6	30	30	6695.5	1079.7	1330.4	4125.0	30
32	6616.8	1051.7	1288.0	4052.1	32	32	6698.2	1080.7	1331.8	4127.5	32
34	6619.5	1052.6	1289.5	4054.6	34	34	6700.9	1081.6	1333.3	4130.0	34
36	6622.3	1053.6	1290.9	4057.1	36	36	6703.6	1082.6	1334.8	4132.6	36
38	6625.0	1054.5	1292.4	4059.6	38	38	6706.3	1083.6	1336.3	4135.1	38
40	6627.7	1055.5	1293.8	4062.1	40	40	6709.0	1084.5	1337.8	4137.7	40
42	6630.4	1056.5	1295.3	4064.6	42	42	6711.7	1085.5	1339.2	4140.2	42
44	6633.1	1057.4	1296.7	4067.1	44	44	6714.4	1086.5	1340.7	4142.7	44
46	6635.9	1058.4	1298.2	4069.6	46	46	6717.2	1087.5	1342.2	4145.3	46
48	6638.6	1059.3	1299.6	4072.1	48	48	6719.9	1088.4	1343.7	4147.8	48
50	6641.3	1060.3	1301.1	4074.6	50	50	6722.6	1089.4	1345.2	4150.4	50
52	6644.0	1061.3	1302.6	4077.1	52	52	6725.3	1090.4	1346.7	4152.9	52
54	6646.7	1062.2	1304.0	4079.6	54	54	6728.0	1091.3	1348.2	4155.4	54
56	6649.5	1063.2	1305.5	4082.1	56	56	6730.7	1092.3	1349.7	4158.0	56
58	6652.2	1064.1	1306.9	4084.6	58	58	6733.4	1093.3	1351.2	4160.5	58
60	6654.9	1065.1	1308.4	4087.1	60	60	6736.1	1094.3	1352.7	4163.1	60

	72°.					73°.					
	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	6736.1	1094.3	1352.7	4163.1	0	0	6816.6	1123.9	1398.1	4240.0	0
2	6738.8	1095.2	1354.2	4165.6	2	2	6819.3	1124.8	1399.6	4242.6	2
4	6741.5	1096.2	1355.7	4168.2	4	4	6821.9	1125.8	1401.2	4245.1	4
6	6744.1	1097.2	1357.2	4170.7	6	6	6824.6	1126.8	1402.7	4247.7	6
8	6746.8	1098.2	1358.7	4173.3	8	8	6827.3	1127.8	1404.2	4250.3	8
10	6749.5	1099.2	1360.2	4175.8	10	10	6830.0	1128.8	1405.8	4252.9	10
12	6752.2	1100.1	1361.7	4178.4	12	12	6832.6	1129.8	1407.3	4255.5	12
14	6754.9	1101.1	1363.2	4181.0	14	14	6835.3	1130.8	1408.8	4258.1	14
16	6757.6	1102.1	1364.7	4183.5	16	16	6838.0	1131.8	1410.4	4260.7	16
18	6760.2	1103.1	1366.2	4186.1	18	18	6840.7	1132.8	1411.9	4263.2	18
20	6762.9	1104.1	1367.7	4188.6	20	20	6843.3	1133.8	1413.5	4265.8	20
22	6765.6	1105.1	1369.2	4191.2	22	22	6846.0	1134.8	1415.1	4268.4	22
24	6768.3	1106.0	1370.7	4193.7	24	24	6848.7	1135.8	1416.6	4271.0	24
26	6771.0	1107.0	1372.2	4196.3	26	26	6851.3	1136.8	1418.2	4273.6	26
28	6773.7	1108.0	1373.7	4198.8	28	28	6854.0	1137.8	1419.7	4276.2	28
30	6776.3	1109.0	1375.2	4201.4	30	30	6856.7	1138.8	1421.3	4278.8	30
32	6779.0	1109.9	1376.7	4204.0	32	32	6859.4	1139.8	1422.9	4281.4	32
34	6781.7	1110.9	1378.2	4206.5	34	34	6862.0	1140.8	1424.4	4284.0	34
36	6784.4	1111.9	1379.7	4209.1	36	36	6864.7	1141.8	1426.0	4286.6	36
38	6787.1	1112.9	1381.2	4211.7	38	38	6867.4	1142.8	1427.5	4289.2	38
40	6789.8	1113.9	1382.8	4214.3	40	40	6870.1	1143.8	1429.1	4291.8	40
42	6792.4	1114.9	1384.3	4216.8	42	42	6872.7	1144.8	1430.7	4294.4	42
44	6795.1	1115.9	1385.8	4219.4	44	44	6875.4	1145.8	1432.2	4297.0	44
46	6797.8	1116.9	1387.4	4222.0	46	46	6878.1	1146.8	1433.8	4299.6	46
48	6800.5	1117.9	1388.9	4224.5	48	48	6880.8	1147.8	1435.3	4302.2	48
50	6803.2	1118.9	1390.4	4227.1	50	50	6883.4	1148.8	1436.9	4304.8	50
52	6805.9	1119.9	1392.0	4229.7	52	52	6886.1	1149.8	1438.5	4307.4	52
54	6808.5	1120.9	1393.5	4232.3	54	54	6888.8	1150.8	1440.0	4310.0	54
56	6811.2	1121.9	1395.0	4234.8	56	56	6891.4	1151.8	1441.6	4312.6	56
58	6813.9	1122.9	1396.6	4237.4	58	58	6894.1	1152.8	1443.1	4315.2	58
60	6816.6	1123.9	1398.1	4240.0	60	60	6896.8	1153.8	1444.7	4317.8	60

74°.						75°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	6896.8	1153.8	1444.7	4317.8	0	0	6976.4	1184.1	1492.5	4396.7	0
2	6899.4	1154.8	1446.2	4320.5	2	2	6979.0	1185.1	1494.1	4399.4	2
4	6902.1	1155.8	1447.8	4323.1	4	4	6981.7	1186.1	1495.7	4402.1	4
6	6904.8	1156.8	1449.4	4325.7	6	6	6984.3	1187.1	1497.3	4404.7	6
8	6907.4	1157.8	1451.0	4328.3	8	8	6986.9	1188.1	1499.0	4407.4	8
10	6910.1	1158.8	1452.6	4330.9	10	10	6989.6	1189.2	1500.6	4410.0	10
12	6912.7	1159.8	1454.1	4333.6	12	12	6992.2	1190.2	1502.2	4412.7	12
14	6915.4	1160.8	1455.7	4336.2	14	14	6994.9	1191.2	1503.8	4415.3	14
16	6918.0	1161.8	1457.3	4338.8	16	16	6997.5	1192.2	1505.4	4418.0	16
18	6920.7	1162.8	1458.9	4341.4	18	18	7000.1	1193.2	1507.0	4420.7	18
20	6923.3	1163.9	1460.5	4344.0	20	20	7002.8	1194.3	1508.7	4423.3	20
22	6926.0	1164.9	1462.0	4346.7	22	22	7005.4	1195.3	1510.3	4426.0	22
24	6928.6	1165.9	1463.6	4349.3	24	24	7008.0	1196.3	1512.0	4428.6	24
26	6931.3	1166.9	1465.2	4351.9	26	26	7010.7	1197.3	1513.6	4431.3	26
28	6933.9	1167.9	1466.8	4354.5	28	28	7013.3	1198.3	1515.3	4434.0	28
30	6936.6	1168.9	1468.4	4357.1	30	30	7015.9	1199.4	1516.9	4436.6	30
32	6939.2	1169.9	1469.9	4359.8	32	32	7018.6	1200.4	1518.5	4439.3	32
34	6941.9	1170.9	1471.5	4362.4	34	34	7021.2	1201.4	1520.2	4442.0	34
36	6944.6	1171.9	1473.1	4365.1	36	36	7023.9	1202.4	1521.8	4444.6	36
38	6947.2	1172.9	1474.7	4367.7	38	38	7026.5	1203.4	1523.5	4447.3	38
40	6949.9	1174.0	1476.4	4370.3	40	40	7029.1	1204.5	1525.1	4450.0	40
42	6952.5	1175.0	1478.0	4373.0	42	42	7031.8	1205.5	1526.7	4452.7	42
44	6955.2	1176.0	1479.6	4375.6	44	44	7034.4	1206.5	1528.4	4455.3	44
46	6957.8	1177.0	1481.2	4378.3	46	46	7037.0	1207.5	1530.0	4458.0	46
48	6960.5	1178.0	1482.8	4380.9	48	48	7039.7	1208.5	1531.7	4460.7	48
50	6963.1	1179.0	1484.4	4383.5	50	50	7042.3	1209.6	1533.3	4463.4	50
52	6965.8	1180.0	1486.0	4386.2	52	52	7045.0	1210.6	1534.9	4466.0	52
54	6968.4	1181.0	1487.7	4388.8	54	54	7047.6	1211.6	1536.6	4468.7	54
56	6971.1	1182.0	1489.3	4391.5	56	56	7050.2	1212.6	1538.2	4471.4	56
58	6973.7	1183.0	1490.9	4394.1	58	58	7052.9	1213.6	1539.9	4474.1	58
	6976.4	1184.1	1492.5	4396.7	60	60	7055.5	1214.7	1541.5	4476.7	60

	76°.						77°.				
MIN.	CHORD.	MID ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	7055.5	1214.7	1541.5	4476.7	0	0	7134.0	1245.6	1591.7	4557.8	0
2	7058.1	1215.7	1543.2	4479.4	2	2	7136.6	1246.6	1593.4	4560.5	2
4	7060.7	1216.7	1544.9	4482.1	4	4	7139.2	1247.7	1595.1	4563.3	4
6	7063.3	1217.8	1546.5	4484.8	6	6	7141.8	1248.7	1596.8	4566.0	6
8	7066.0	1218.8	1548.2	4487.5	8	8	7144.4	1249.8	1598.5	4568.7	8
10	7068.6	1219.8	1549.9	4490.2	10	10	7147.0	1250.8	1600.2	4571.5	10
12	7071.2	1220.9	1551.5	4492.9	12	12	7149.6	1251.8	1601.9	4574.2	12
14	7073.8	1221.9	1553.2	4495.6	14	14	7152.2	1252.9	1603.6	4576.9	14
16	7076.4	1222.9	1554.9	4498.3	16	16	7154.8	1253.9	1605.3	4579.7	16
18	7079.0	1224.0	1556.5	4501.0	18	18	7157.4	1255.0	1607.0	4582.4	18
20	7081.7	1225.0	1558.2	4503.7	20	20	7160.0	1256.0	1608.7	4585.1	20
22	7084.3	1226.0	1559.9	4506.3	22	22	7162.6	1257.0	1610.4	4587.9	22
24	7086.9	1227.1	1561.5	4509.0	24	24	7165.2	1258.1	1612.1	4590.6	24
26	7089.5	1228.1	1563.2	4511.7	26	26	7167.8	1259.1	1613.8	4593.3	26
28	7092.1	1229.1	1564.9	4514.4	28	28	7170.4	1260.2	1615.5	4596.0	28
30	7094.7	1230.2	1566.5	4517.1	30	30	7173.0	1261.2	1617.3	4598.8	30
32	7097.4	1231.2	1568.2	4519.8	32	32	7175.6	1262.2	1619.0	4601.5	32
34	7100.0	1232.2	1569.9	4522.5	34	34	7178.2	1263.3	1620.7	4604.3	34
36	7102.6	1233.3	1571.5	4525.3	36	36	7180.8	1264.3	1622.4	4607.0	36
38	7105.2	1234.3	1573.2	4528.0	38	38	7183.4	1265.4	1624.1	4609.8	38
40	7107.8	1235.3	1574.8	4530.7	40	40	7186.0	1266.4	1625.9	4612.5	40
42	7110.4	1236.4	1576.4	4533.4	42	42	7188.6	1267.4	1627.6	4615.3	42
44	7113.1	1237.4	1578.1	4536.1	44	44	7191.2	1268.5	1629.3	4618.0	44
46	7115.7	1238.4	1579.8	4538.8	46	46	7193.8	1269.5	1631.0	4620.8	46
48	7118.3	1239.5	1581.5	4541.5	48	48	7196.4	1270.6	1632.7	4623.5	48
50	7120.9	1240.5	1583.2	4544.2	50	50	7199.0	1271.6	1634.5	4626.3	50
52	7123.5	1241.5	1584.9	4547.0	52	52	7201.6	1272.7	1636.2	4629.0	52
54	7126.1	1242.6	1586.6	4549.7	54	54	7204.2	1273.7	1637.9	4631.8	54
56	7128.8	1243.6	1588.3	4552.4	56	56	7206.8	1274.8	1639.6	4634.5	56
58	7131.4	1244.6	1590.0	4555.1	58	58	7209.4	1275.8	1641.3	4637.3	58
60	7134.0	1245.6	1591.7	4557.8	60	60	7212.0	1276.9	1643.1	4640.0	60

78°.						79°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	7212.0	1276.9	1643.1	4640.0	0	0	7289.5	1308.5	1696.0	4723.4	0
2	7214.6	1278.0	1644.8	4642.8	2	2	7292.1	1309.5	1697.7	4726.2	2
4	7217.2	1279.0	1646.6	4645.6	4	4	7294.6	1310.6	1699.5	4729.0	4
6	7219.7	1280.1	1648.3	4648.3	6	6	7297.2	1311.7	1701.3	4731.8	6
8	7222.3	1281.1	1650.1	4651.1	8	8	7299.7	1312.7	1703.1	4734.7	8
10	7224.9	1282.2	1651.8	4653.9	10	10	7302.3	1313.8	1704.9	4737.5	10
12	7227.5	1283.2	1653.6	4656.7	12	12	7304.9	1314.9	1706.6	4740.3	12
14	7230.1	1284.3	1655.3	4659.4	14	14	7307.4	1315.9	1708.4	4743.1	14
16	7232.7	1285.3	1657.1	4662.2	16	16	7310.0	1317.0	1710.2	4745.9	16
18	7235.2	1286.4	1658.8	4665.0	18	18	7312.6	1318.1	1712.0	4748.7	18
20	7237.8	1287.4	1660.6	4667.7	20	20	7315.1	1319.1	1713.8	4751.5	20
22	7240.4	1288.5	1662.3	4670.5	22	22	7317.7	1320.2	1715.6	4754.3	22
24	7243.0	1289.5	1664.1	4673.3	24	24	7320.3	1321.3	1717.4	4757.1	24
26	7245.6	1290.6	1665.8	4676.0	26	26	7322.8	1322.3	1719.2	4760.0	26
28	7248.2	1291.6	1667.6	4678.8	28	28	7325.4	1323.4	1721.0	4762.8	28
30	7250.7	1292.7	1669.3	4681.6	30	30	7327.9	1324.5	1722.8	4765.6	30
32	7253.3	1293.7	1671.1	4684.4	32	32	7330.5	1325.5	1724.6	4768.4	32
34	7255.9	1294.8	1672.8	4687.2	34	34	7333.1	1326.6	1726.4	4771.2	34
36	7258.5	1295.8	1674.6	4689.9	36	36	7335.6	1327.7	1728.2	4774.1	36
38	7261.1	1296.9	1676.3	4692.7	38	38	7338.2	1328.7	1730.0	4776.9	38
40	7263.7	1297.9	1678.2	4695.5	40	40	7340.8	1329.8	1731.9	4779.7	40
42	7266.2	1299.0	1679.9	4698.3	42	42	7343.3	1330.8	1733.7	4782.6	42
44	7268.8	1300.0	1681.7	4701.1	44	44	7345.9	1331.9	1735.5	4785.4	44
46	7271.4	1301.1	1683.5	4703.9	46	46	7348.4	1333.0	1737.3	4788.2	46
48	7274.0	1302.1	1685.3	4706.7	48	48	7351.0	1334.1	1739.1	4791.0	48
50	7276.6	1303.2	1687.1	4709.5	50	50	7353.6	1335.2	1740.9	4793.9	50
52	7279.2	1304.2	1688.8	4712.2	52	52	7356.1	1336.2	1742.7	4796.7	52
54	7281.7	1305.3	1690.6	4715.0	54	54	7358.7	1337.3	1744.5	4799.5	54
56	7284.3	1306.3	1692.4	4717.8	56	56	7361.3	1338.4	1746.3	4802.4	56
58	7286.9	1307.4	1694.2	4720.6	58	58	7363.8	1339.5	1748.1	4805.2	58
	7289.5	1308.5	1696.0	4723.4	60	60	7366.4	1340.6	1750.0	4808.0	60

	84°.					85°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	7668.3	1471.8	1980.5	5159.3	0	0	7742.4	1505.4	2041.8	5250.6	0
2	7670.8	1472.9	1982.5	5162.3	2	2	7744.8	1506.5	2043.9	5253.6	2
4	7673.2	1474.0	1984.5	5165.3	4	4	7747.3	1507.6	2046.0	5256.7	4
6	7675.7	1475.1	1986.6	5168.4	6	6	7749.7	1508.8	2048.0	5259.8	6
8	7678.2	1476.2	1988.6	5171.4	8	8	7752.2	1509.9	2050.1	5262.9	8
10	7680.6	1477.4	1990.6	5174.4	10	10	7754.6	1511.0	2052.2	5266.0	10
12	7683.1	1478.5	1992.7	5177.5	12	12	7757.1	1512.2	2054.2	5269.0	12
14	7685.6	1479.6	1994.7	5180.5	14	14	7759.5	1513.3	2056.3	5272.1	14
16	7688.1	1480.7	1996.7	5183.5	16	16	7762.0	1514.4	2058.4	5275.2	16
18	7690.5	1481.8	1998.8	5186.6	18	18	7764.4	1515.6	2060.5	5278.3	18
20	7693.0	1483.0	2000.8	5189.6	20	20	7766.9	1516.7	2062.6	5281.4	20
22	7695.5	1484.1	2002.8	5192.6	22	22	7769.3	1517.8	2064.7	5284.4	22
24	7697.9	1485.2	2004.9	5195.6	24	24	7771.8	1519.0	2066.8	5287.5	24
26	7700.4	1486.3	2006.9	5198.7	26	26	7774.2	1520.1	2068.9	5290.6	26
28	7702.9	1487.4	2008.9	5201.7	28	28	7776.7	1521.2	2071.0	5293.7	28
30	7705.3	1488.6	2011.0	5204.7	30	30	7779.1	1522.4	2073.1	5296.7	30
32	7707.8	1489.7	2013.0	5207.8	32	32	7781.5	1523.5	2075.2	5299.8	32
34	7710.3	1490.8	2015.0	5210.8	34	34	7784.0	1524.6	2077.3	5302.9	34
36	7712.8	1491.9	2017.0	5213.9	36	36	7786.4	1525.8	2079.4	5306.1	36
38	7715.2	1493.0	2019.1	5216.9	38	38	7788.9	1526.9	2081.5	5309.2	38
40	7717.7	1494.2	2021.2	5220.0	40	40	7791.3	1528.0	2083.7	5312.3	40
42	7720.2	1495.3	2023.2	5223.1	42	42	7793.8	1529.2	2085.8	5315.4	42
44	7722.6	1496.4	2025.3	5226.1	44	44	7796.2	1530.3	2087.9	5318.5	44
46	7725.1	1497.5	2027.4	5229.2	46	46	7798.7	1531.4	2090.0	5321.6	46
48	7727.6	1498.6	2029.4	5232.2	48	48	7801.1	1532.6	2092.1	5324.7	48
50	7730.0	1499.8	2031.5	5235.3	50	50	7803.6	1533.7	2094.2	5327.8	50
52	7732.5	1500.9	2033.6	5238.3	52	52	7806.0	1534.8	2096.3	5330.9	52
54	7735.0	1502.0	2035.6	5241.4	54	54	7808.5	1536.0	2098.4	5334.0	54
56	7737.5	1503.1	2037.7	5244.5	56	56	7810.9	1537.1	2100.6	5337.1	56
58	7739.9	1504.2	2039.8	5247.5	58	58	7813.4	1538.2	2102.7	5340.2	58
60	7742.4	1505.4	2041.8	5250.6	60	60	7815.8	1539.3	2104.8	5343.3	60

	86°.					87°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	7815.8	1539.3	2104.8	5343.3	0	0	7888.5	1573.6	2169.5	5437.5	0
2	7818.2	1540.4	2106.9	5346.4	2	2	7890.9	1574.8	2171.6	5440.7	2
4	7820.6	1541.6	2109.1	5349.5	4	4	7893.3	1575.9	2173.8	5443.9	4
6	7823.1	1542.7	2111.2	5352.7	6	6	7895.7	1577.1	2176.0	5447.1	6
8	7825.5	1543.9	2113.4	5355.8	8	8	7898.1	1578.2	2178.2	5450.3	8
10	7827.9	1545.0	2115.5	5358.9	10	10	7900.5	1579.4	2180.4	5453.4	10
12	7830.3	1546.1	2117.6	5362.0	12	12	7903.0	1580.5	2182.5	5456.6	12
14	7832.8	1547.3	2119.8	5365.2	14	14	7905.4	1581.7	2184.7	5459.8	14
16	7835.2	1548.4	2121.9	5368.3	16	16	7907.8	1582.9	2186.9	5463.0	16
18	7837.6	1549.6	2124.1	5371.4	18	18	7910.2	1584.0	2189.1	5466.2	18
20	7840.0	1550.7	2126.2	5374.6	20	20	7912.6	1585.1	2191.3	5469.4	20
22	7842.4	1551.8	2128.3	5377.7	22	22	7915.0	1586.3	2193.5	5472.5	22
24	7844.9	1553.0	2130.5	5380.8	24	24	7917.4	1587.4	2195.7	5475.7	24
26	7847.3	1554.1	2132.6	5383.9	26	26	7919.8	1588.6	2197.9	5478.9	26
28	7849.7	1555.3	2134.8	5387.1	28	28	7922.2	1589.7	2200.1	5482.1	28
30	7852.1	1556.4	2136.9	5390.2	30	30	7924.6	1590.9	2202.3	5485.3	30
32	7854.6	1557.5	2139.0	5393.4	32	32	7927.1	1592.0	2204.5	5488.5	32
34	7857.0	1558.7	2141.2	5396.5	34	34	7929.5	1593.2	2206.8	5491.7	34
36	7859.4	1559.8	2143.3	5399.7	36	36	7931.9	1594.3	2209.0	5494.9	36
38	7861.8	1561.0	2145.5	5402.8	38	38	7934.3	1595.5	2211.2	5498.1	38
40	7864.3	1562.1	2147.7	5406.0	40	40	7936.7	1596.6	2213.4	5501.3	40
42	7866.7	1563.2	2149.8	5409.1	42	42	7939.1	1597.8	2215.6	5504.5	42
44	7869.1	1564.4	2152.0	5412.3	44	44	7941.5	1598.9	2217.8	5507.7	44
46	7871.5	1565.5	2154.2	5415.4	46	46	7943.9	1600.1	2220.0	5510.9	46
48	7874.0	1566.7	2156.4	5418.6	48	48	7946.3	1601.2	2222.3	5514.1	48
50	7876.4	1567.8	2158.6	5421.8	50	50	7948.7	1602.4	2224.5	5517.3	50
52	7878.8	1568.9	2160.7	5424.9	52	52	7951.2	1603.5	2226.7	5520.5	52
54	7881.2	1570.1	2162.9	5428.1	54	54	7953.6	1604.7	2228.9	5523.7	54
56	7883.6	1571.2	2165.1	5431.2	56	56	7956.0	1605.8	2231.1	5526.9	56
58	7886.1	1572.4	2167.3	5434.4	58	58	7958.4	1607.0	2233.3	5530.1	58
60	7888.5	1573.6	2169.5	5437.5	60	60	7960.8	1608.2	2235.6	5533.3	60

84°.						85°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	7668.3	1471.8	1980.5	5159.3	0	0	7742.4	1505.4	2041.8	5250.6	0
2	7670.8	1472.9	1982.5	5162.3	2	2	7744.8	1506.5	2043.9	5253.6	2
4	7673.2	1474.0	1984.5	5165.3	4	4	7747.3	1507.6	2046.0	5256.7	4
6	7675.7	1475.1	1986.6	5168.4	6	6	7749.7	1508.8	2048.0	5259.8	6
8	7678.2	1476.2	1988.6	5171.4	8	8	7752.2	1509.9	2050.1	5262.9	8
10	7680.6	1477.4	1990.6	5174.4	10	10	7754.6	1511.0	2052.2	5266.0	10
12	7683.1	1478.5	1992.7	5177.5	12	12	7757.1	1512.2	2054.2	5269.0	12
14	7685.6	1479.6	1994.7	5180.5	14	14	7759.5	1513.3	2056.3	5272.1	14
16	7688.1	1480.7	1996.7	5183.5	16	16	7762.0	1514.4	2058.4	5275.2	16
18	7690.5	1481.8	1998.8	5186.6	18	18	7764.4	1515.6	2060.5	5278.3	18
20	7693.0	1483.0	2000.8	5189.6	20	20	7766.9	1516.7	2062.6	5281.4	20
22	7695.5	1484.1	2002.8	5192.6	22	22	7769.3	1517.8	2064.7	5284.4	22
24	7697.9	1485.2	2004.9	5195.6	24	24	7771.8	1519.0	2066.8	5287.5	24
26	7700.4	1486.3	2006.9	5198.7	26	26	7774.2	1520.1	2068.9	5290.6	26
28	7702.9	1487.4	2008.9	5201.7	28	28	7776.7	1521.2	2071.0	5293.7	28
30	7705.3	1488.6	2011.0	5204.7	30	30	7779.1	1522.4	2073.1	5296.7	30
32	7707.8	1489.7	2013.0	5207.8	32	32	7781.5	1523.5	2075.2	5299.8	32
34	7710.3	1490.8	2015.0	5210.8	34	34	7784.0	1524.6	2077.3	5302.9	34
36	7712.8	1491.9	2017.0	5213.9	36	36	7786.4	1525.8	2079.4	5306.1	36
38	7715.2	1493.0	2019.1	5216.9	38	38	7788.9	1526.9	2081.5	5309.2	38
40	7717.7	1494.2	2021.2	5220.0	40	40	7791.3	1528.0	2083.7	5312.3	40
42	7720.2	1495.3	2023.2	5223.1	42	42	7793.8	1529.2	2085.8	5315.4	42
44	7722.6	1496.4	2025.3	5226.1	44	44	7796.2	1530.3	2087.9	5318.5	44
46	7725.1	1497.5	2027.4	5229.2	46	46	7798.7	1531.4	2090.0	5321.6	46
48	7727.6	1498.6	2029.4	5232.2	48	48	7801.1	1532.6	2092.1	5324.7	48
50	7730.0	1499.8	2031.5	5235.3	50	50	7803.6	1533.7	2094.2	5327.8	50
52	7732.5	1500.9	2033.6	5238.3	52	52	7806.0	1534.8	2096.3	5330.9	52
54	7735.0	1502.0	2035.6	5241.4	54	54	7808.5	1536.0	2098.4	5334.0	54
56	7737.5	1503.1	2037.7	5244.5	56	56	7810.9	1537.1	2100.6	5337.1	56
58	7739.9	1504.2	2039.8	5247.5	58	58	7813.4	1538.2	2102.7	5340.2	58
60	7742.4	1505.4	2041.8	5250.6	60	60	7815.8	1539.3	2104.8	5343.3	60

86°.						87°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	7815.8	1539.3	2104.8	5343.3	0	0	7888.5	1573.6	2169.5	5437.5	0
2	7818.2	1540.4	2106.9	5346.4	2	2	7890.9	1574.8	2171.6	5440.7	2
4	7820.6	1541.6	2109.1	5349.5	4	4	7893.3	1575.9	2173.8	5443.9	4
6	7823.1	1542.7	2111.2	5352.7	6	6	7895.7	1577.1	2176.0	5447.1	6
8	7825.5	1543.9	2113.4	5355.8	8	8	7898.1	1578.2	2178.2	5450.3	8
10	7827.9	1545.0	2115.5	5358.9	10	10	7900.5	1579.4	2180.4	5453.4	10
12	7830.3	1546.1	2117.6	5362.0	12	12	7903.0	1580.5	2182.5	5456.6	12
14	7832.8	1547.3	2119.8	5365.2	14	14	7905.4	1581.7	2184.7	5459.8	14
16	7835.2	1548.4	2121.9	5368.3	16	16	7907.8	1582.9	2186.9	5463.0	16
18	7837.6	1549.6	2124.1	5371.4	18	18	7910.2	1584.0	2189.1	5466.2	18
20	7840.0	1550.7	2126.2	5374.6	20	20	7912.6	1585.1	2191.3	5469.4	20
22	7842.4	1551.8	2128.3	5377.7	22	22	7915.0	1586.3	2193.5	5472.5	22
24	7844.9	1553.0	2130.5	5380.8	24	24	7917.4	1587.4	2195.7	5475.7	24
26	7847.3	1554.1	2132.6	5383.9	26	26	7919.8	1588.6	2197.9	5478.9	26
28	7849.7	1555.3	2134.8	5387.1	28	28	7922.2	1589.7	2200.1	5482.1	28
30	7852.1	1556.4	2136.9	5390.2	30	30	7924.6	1590.9	2202.3	5485.3	30
32	7854.6	1557.5	2139.0	5393.4	32	32	7927.1	1592.0	2204.5	5488.5	32
34	7857.0	1558.7	2141.2	5396.5	34	34	7929.5	1593.2	2206.8	5491.7	34
36	7859.4	1559.8	2143.3	5399.7	36	36	7931.9	1594.3	2209.0	5494.9	36
38	7861.8	1561.0	2145.5	5402.8	38	38	7934.3	1595.5	2211.2	5498.1	38
40	7864.3	1562.1	2147.7	5406.0	40	40	7936.7	1596.6	2213.4	5501.3	40
42	7866.7	1563.2	2149.8	5409.1	42	42	7939.1	1597.8	2215.6	5504.5	42
44	7869.1	1564.4	2152.0	5412.3	44	44	7941.5	1598.9	2217.8	5507.7	44
46	7871.5	1565.5	2154.2	5415.4	46	46	7943.9	1600.1	2220.0	5510.9	46
48	7874.0	1566.7	2156.4	5418.6	48	48	7946.3	1601.2	2222.3	5514.1	48
50	7876.4	1567.8	2158.6	5421.8	50	50	7948.7	1602.4	2224.5	5517.3	50
52	7878.8	1568.9	2160.7	5424.9	52	52	7951.2	1603.5	2226.7	5520.5	52
54	7881.2	1570.1	2162.9	5428.1	54	54	7953.6	1604.7	2228.9	5523.7	54
56	7883.6	1571.2	2165.1	5431.2	56	56	7956.0	1605.8	2231.1	5526.9	56
58	7886.1	1572.4	2167.3	5434.4	58	58	7958.4	1607.0	2233.3	5530.1	58
60	7888.5	1573.6	2169.5	5437.5	60	60	7960.8	1608.2	2235.6	5533.3	60

88°.						89°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	7960.8	1608.2	2235.6	5533.3	0	0	8032.4	1643.0	2303.6	5630.8	0
2	7963.2	1609.4	2237.8	5536.6	2	2	8034.8	1644.1	2305.9	5634.1	2
4	7965.6	1610.5	2240.1	5539.8	4	4	8037.1	1645.3	2308.2	5637.4	4
6	7968.0	1611.7	2242.3	5543.1	6	6	8039.5	1646.5	2310.5	5640.7	6
8	7970.3	1612.8	2244.6	5546.3	8	8	8041.9	1647.7	2312.8	5644.0	8
10	7972.7	1614.0	2246.8	5549.5	10	10	8044.2	1648.9	2315.1	5647.3	10
12	7975.1	1615.2	2249.1	5552.8	12	12	8046.6	1650.0	2317.4	5650.6	12
14	7977.5	1616.3	2251.3	5556.0	14	14	8049.0	1651.2	2319.7	5653.9	14
16	7979.9	1617.5	2253.6	5559.2	16	16	8051.4	1652.4	2322.0	5657.1	16
18	7982.3	1618.6	2255.8	5562.5	18	18	8053.7	1653.6	2324.3	5660.4	18
20	7984.7	1619.8	2258.1	5565.7	20	20	8056.1	1654.8	2326.7	5663.7	20
22	7987.1	1621.0	2260.4	5568.9	22	22	8058.5	1655.9	2329.0	5667.0	22
24	7989.4	1622.1	2262.7	5572.2	24	24	8060.8	1657.1	2331.3	5670.3	24
26	7991.8	1623.3	2264.9	5575.4	26	26	8063.2	1658.3	2333.7	5673.6	26
28	7994.2	1624.4	2267.2	5578.6	28	28	8065.6	1659.5	2336.0	5676.9	28
30	7996.6	1625.6	2269.5	5581.9	30	30	8067.9	1660.7	2338.3	5680.2	30
32	7999.0	1626.8	2271.7	5585.1	32	32	8070.3	1661.8	2340.7	5683.5	32
34	8001.4	1627.9	2273.9	5588.4	34	34	8073.7	1663.0	2343.0	5686.8	34
36	8003.8	1629.1	2276.2	5591.7	36	36	8075.1	1664.2	2345.3	5690.2	36
38	8006.1	1630.2	2278.5	5594.9	38	38	8077.4	1665.4	2347.7	5693.5	38
40	8008.5	1631.4	2280.8	5598.2	40	40	8079.8	1666.6	2350.0	5696.8	40
42	8010.9	1632.6	2283.0	5601.4	42	42	8082.2	1667.7	2352.3	5700.1	42
44	8013.3	1633.7	2285.3	5604.7	44	44	8084.5	1668.8	2354.7	5703.4	44
46	8015.7	1634.9	2287.6	5608.0	46	46	8086.9	1670.0	2357.0	5706.8	46
48	8018.1	1636.0	2289.9	5611.2	48	48	8089.3	1671.2	2359.3	5710.1	48
50	8020.5	1637.2	2292.2	5614.5	50	50	8091.6	1672.4	2361.7	5713.4	50
52	8022.9	1638.4	2294.4	5617.8	52	52	8094.0	1673.5	2364.0	5716.7	52
54	8025.2	1639.5	2296.7	5621.0	54	54	8096.4	1674.7	2366.3	5720.0	54
56	8027.6	1640.7	2299.0	5624.3	56	56	8098.8	1675.9	2368.7	5723.4	56
58	8030.0	1641.8	2301.3	5627.5	58	58	8101.1	1677.1	2371.0	5726.7	58
60	8032.4	1643.0	2303.6	5630.8	60	60	8103.5	1678.3	2373.4	5730.0	60

90°.						91°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	8103.5	1678.3	2373.4	5730.0	0	0	8173.9	1713.8	2445.1	5830.9	0
2	8105.8	1679.5	2375.8	5733.3	2	2	8176.2	1715.0	2447.5	5834.3	2
4	8108.2	1680.6	2378.2	5736.7	4	4	8178.5	1716.2	2450.0	5837.7	4
6	8110.5	1681.8	2380.5	5740.0	6	6	8180.9	1717.4	2452.4	5841.1	6
8	8112.9	1683.0	2382.9	5743.4	8	8	8183.2	1718.6	2454.8	5844.5	8
10	8115.2	1684.2	2385.3	5746.7	10	10	8185.5	1719.7	2457.2	5847.9	10
12	8117.6	1685.4	2387.6	5750.0	12	12	8187.9	1720.9	2459.7	5851.3	12
14	8119.9	1686.5	2390.0	5753.4	14	14	8190.2	1722.1	2462.1	5854.7	14
16	8122.3	1687.7	2392.4	5756.7	16	16	8192.5	1723.3	2464.5	5858.1	16
18	8124.6	1688.9	2394.7	5760.1	18	18	8194.8	1724.5	2467.0	5861.5	18
20	8127.0	1690.1	2397.1	5763.4	20	20	8197.2	1725.7	2469.4	5864.9	20
22	8129.3	1691.3	2399.5	5766.8	22	22	8199.5	1726.9	2471.9	5868.3	22
24	8131.7	1692.5	2401.9	5770.1	24	24	8201.8	1728.1	2474.3	5871.8	24
26	8134.0	1693.6	2404.3	5773.5	26	26	8204.2	1729.3	2476.7	5875.2	26
28	8136 4	1694.8	2406.6	5776.9	28	28	8206.5	1730.5	2479.2	5878.6	28
30	8138.7	1696.0	2409.0	5780.2	30	30	8208.8	1731.7	2481.6	5882.0	30
32	8141.1	1697.2	2411.4	5783.6	32	32	8211.1	1732.9	2484.1	5885.4	32
34	8143.4	1698.4	2413.8	5787.0	34	34	8213.5	1734.1	2486.5	5888.9	34
36	8145.8	1699.6	2416.2	5790.3	36	36	8215.8	1735.3	2489.0	5892.3	36
38	8148.1	1700.7	2418.6	5793.7	38	38	8218.1	1736.4	2491.5	5895.7	38
40	8150.4	1701.9	2421.0	5797.1	40	40	8220.4	1737.6	2493.9	5899.2	40
42	8152.8	1703 1	2423.4	5800.4	42	42	8222.8	1738.8	2496.4	5902.6	42
44	8155.1	1704.3	2425.8	5803.8	44	44	8225.1	1740.0	2498.9	5906.0	44
46	8157.5	1705.5	2428.2	5807.2	46	46	8227.4	1741.2	2501.3	5909.4	46
48	8159.8	1706.7	2430.6	5810.6	48	48	8229.7	1742.4	2503.8	5912.9	48
50	8162.2	1707.9	2433.0	5814.0	50	50	8232 0	1743.6	2506.3	5916.3	50
52	8164.5	1709.0	2435.4	5817.3	52	52	8234.3	1744.8	2508.7	5919.8	52
	8166.8	1710.2	2437.9	5820.7	54	54	8236.7	1746.0	2511.2	5923.2	54
	8169.2	1711.4	2440.3	5824.1	56	56	8239.0	1747.2	2513.7	5926.7	56
	8171.5	1712.6	2442.7	5827.5	58	58	8241.3	1748.4	2516.2	5930.1	58
	8173.9	1713 8	2445.1	5830.9	60	60	8243.6	1749.6	2518.7	5933.6	60

92°.						93°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	8243.6	1749.6	2518.7	5933.6	0	0	8312.8	1785.7	2594.2	6038.2	0
2	8245.9	1750.8	2521.2	5937.0	2	2	8315.1	1786.9	2596.8	6041.7	2
4	8248.2	1752.0	2523.6	5940.5	4	4	8317.4	1788.2	2599.3	6045.2	4
6	8250.6	1753.2	2526.1	5944.0	6	6	8319.7	1789.4	2601.9	6048.7	6
8	8252.9	1754.4	2528.6	5947.4	8	8	8322.0	1790.6	2604.4	6052.2	8
10	8255.2	1755.6	2531.1	5950.9	10	10	8324.3	1791.8	2607.0	6055.8	10
12	8257.5	1756.8	2533.6	5954.4	12	12	8326.6	1793.0	2609.6	6059.3	12
14	8259.8	1758.0	2536.1	5957.8	14	14	8328.8	1794.2	2612.1	6062.8	14
16	8262.2	1759.2	2538.6	5961.3	16	16	8331.1	1795.4	2614.7	6066.4	16
18	8264.5	1760.4	2541.1	5964.8	18	18	8333.3	1796.6	2617.3	6069.9	18
20	8266.8	1761.6	2543.6	5968.2	20	20	8335.6	1797.8	2619.8	6073.4	20
22	8269.1	1762.8	2546.1	5971.7	22	22	8337.9	1799.1	2622.4	6077.0	22
24	8271.4	1764.0	2548.6	5975.2	24	24	8340.2	1800.3	2625.0	6080.5	24
26	8273.7	1765.2	2551.2	5978.7	26	26	8342.5	1801.5	2627.6	6084.1	26
28	8276.0	1766.4	2553.7	5982.2	28	28	8344.8	1802.7	2630.2	6087.6	28
30	8278.3	1767.6	2556.2	5985.6	30	30	8347.1	1803.9	2632.7	6091.2	30
32	8280.6	1768.8	2558.7	5989.1	32	32	8349.4	1805.1	2635.3	6094.7	32
34	8282.9	1770.0	2561.2	5992.6	34	34	8351.7	1806.3	2637.9	6098.3	34
36	8285.2	1771.2	2563.8	5996.1	36	36	8354.0	1807.6	2640.5	6101.8	36
38	8287.5	1772.5	2566.3	5999.6	38	38	8356.3	1808.8	2643.1	6105.4	38
40	8289.8	1773.7	2568.8	6003.1	40	40	8358.5	1810.0	2645.7	6109.0	40
42	8292.1	1774.9	2571.3	6006.6	42	42	8360.8	1811.2	2648.3	6112.5	42
44	8294.4	1776.1	2573.9	6010.1	44	44	8363.1	1812.4	2650.9	6116.1	44
46	8296.7	1777.3	2576.4	6013.6	46	46	8365.4	1813.6	2653.5	6119.7	46
48	8299.0	1778.5	2578.9	6017.1	48	48	8367.7	1814.9	2656.1	6123.2	48
50	8301.3	1779.7	2581.5	6020.6	50	50	8369.9	1816.1	2658.7	6126.8	50
52	8303.6	1780.9	2584.0	6024.1	52	52	8372.2	1817.3	2661.3	6130.4	52
54	8305.9	1782.1	2586.6	6027.6	54	54	8374.5	1818.5	2663.9	6133.9	54
56	8308.2	1783.3	2589.1	6031.1	56	56	8376.8	1819.7	2666.6	6137.5	56
58	8310.5	1784.5	2591.7	6034.6	58	58	8379.1	1820.9	2669.2	6141.1	58
60	8312.8	1785.7	2594.2	6038.2	60	60	8381.3	1822.2	2671.8	6144.7	60

94°.						95°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	8381.3	1822.2	2671.8	6144.7	0	0	8449.2	1858.9	2751.5	6253.2	0
2	8383.6	1823.4	2674.4	6148.3	2	2	8451.5	1860.1	2754.2	6256.9	2
4	8385.9	1824.6	2677.0	6151.9	4	4	8453.7	1861.3	2756.9	6260.5	4
6	8388.1	1825.8	2679.7	6155.4	6	6	8456.0	1862.6	2759.6	6264.2	6
8	8390.4	1827.0	2682.3	6159.0	8	8	8458.2	1863.8	2762.3	6267.8	8
10	8392.7	1828.3	2684.9	6162.6	10	10	8460.4	1865.0	2765.0	6271.5	10
12	8395.0	1829.5	2687.6	6166.2	12	12	8462.7	1866.3	2767.7	6275.2	12
14	8397.2	1830.7	2690.2	6169.8	14	14	8464.9	1867.5	2770.4	6278.8	14
16	8399.5	1831.9	2692.8	6173.4	16	16	8467.2	1868.7	2773.1	6282.5	16
18	8401.7	1833.1	2695.6	6177.0	18	18	8469.4	1869.9	2775.8	6286.2	18
20	8404.0	1834.4	2698.1	6180.6	20	20	8471.7	1871.2	2778.5	6289.8	20
22	8406.3	1835.6	2700.8	6184.2	22	22	8473.9	1872.4	2781.2	6293.5	22
24	8408.5	1836.8	2703.4	6187.8	24	24	8476.2	1873.6	2784.0	6297.2	24
26	8410.8	1838.0	2706.1	6191.5	26	26	8478.4	1874.9	2786.7	6300.9	26
28	8413.1	1839.3	2708.7	6195.1	28	28	8480.7	1876.1	2789.4	6304.6	28
30	8415.3	1840.5	2711.4	6198.7	30	30	8482.9	1877.3	2792.1	6308.2	30
32	8417.6	1841.7	2714.0	6202.3	32	32	8485.1	1878.6	2794.9	6311.9	32
34	8419.9	1842.9	2716.7	6205.9	34	34	8487.4	1879.8	2797.6	6315.6	34
36	8422.1	1844.2	2719.3	6209.5	36	36	8489.6	1881.0	2800.3	6319.3	36
38	8424.4	1845.4	2722.0	6213.2	38	38	8491.9	1882.3	2803.1	6323.0	38
40	8426.6	1846.6	2724.7	6216.8	40	40	8494.1	1883.5	2805.8	6326.7	40
42	8428.9	1847.8	2727.3	6220.4	42	42	8496.3	1884.8	2808.6	6330.4	42
44	8431.2	1849.1	2730.0	6224.1	44	44	8498.6	1886.0	2811.3	6334.1	44
46	8433.4	1850.3	2732.7	6227.7	46	46	8500.8	1887.2	2814.1	6337.8	46
48	8435.7	1851.5	2735.4	6231.3	48	48	8503.0	1888.5	2816.8	6341.5	48
50	8437.9	1852.7	2738.0	6235.0	50	50	8505.3	1889.7	2819.6	6345.2	50
52	8440.2	1854.0	2740.7	6238.6	52	52	8507.5	1890.9	2822.3	6349.0	52
54	8442.4	1855.2	2743.4	6242.3	54	54	8509.8	1892.2	2825.1	6352.7	54
56	8444.7	1856.4	2746.1	6245.9	56	56	8512.0	1893.4	2827.8	6356.4	56
58	8447.0	1857.6	2748.8	6249.6	58	58	8514.2	1894.6	2830.6	6360.1	58
60	8449.2	1858.9	2751.5	6253.2	60	60	8516.4	1895.9	2833.4	6363.8	60

96°.						97°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	8516.4	1895.9	2833.4	6363.8	0	0	8583.0	1933.2	2917.5	6476.6	0
2	8518.7	1897.1	2836.1	6367.5	2	2	8585.2	1934.4	2920.3	6480.4	2
4	8520.9	1898.4	2838.9	6371.3	4	4	8587.5	1935.7	2923.2	6484.2	4
6	8523.1	1899.6	2841.7	6375.0	6	6	8589.7	1936.9	2926.0	6488.0	6
8	8525.4	1900.8	2844.5	6378.7	8	8	8591.9	1938.2	2928.9	6491.8	8
10	8527.6	1902.1	2847.2	6382.5	10	10	8594.1	1939.4	2931.7	6495.6	10
12	8529.8	1903.3	2850.0	6386.2	12	12	8596.3	1940.7	2934.6	6499.4	12
14	8532.0	1904.6	2852.8	6389.9	14	14	8598.5	1941.9	2937.5	6503.2	14
16	8534.3	1905.8	2855.6	6393.7	16	16	8600.7	1943.2	2940.3	6507.1	16
18	8536.5	1907.0	2858.4	6397.4	18	18	8602.9	1944.4	2943.2	6510.9	18
20	8538.7	1908.3	2861.2	6401.2	20	20	8605.1	1945.7	2946.1	6514.7	20
22	8540.9	1909.5	2864.0	6404.9	22	22	8607.3	1946.9	2948.9	6518.5	22
24	8543.2	1910.8	2866.7	6408.7	24	24	8609.5	1948.2	2951.8	6522.3	24
26	8545.4	1912.0	2869.5	6412.4	26	26	8611.7	1949.4	2954.7	6526.2	26
28	8547.6	1913.3	2872.3	6416.2	28	28	8613.9	1950.7	2957.6	6530.0	28
30	8549.8	1914.5	2875.1	6419.9	30	30	8616.1	1952.0	2960.4	6533.8	30
32	8552.0	1915.7	2877.9	6423.7	32	32	8618.3	1953.2	2963.3	6537.7	32
34	8554.3	1917.0	2880.8	6427.5	34	34	8620.5	1954.5	2966.2	6541.5	34
36	8556.5	1918.2	2883.6	6431.2	36	36	8622.7	1955.7	2969.1	6545.3	36
38	8558.7	1919.5	2886.4	6435.0	38	38	8624.9	1957.0	2972.0	6549.2	38
40	8560.9	1920.7	2889.2	6438.8	40	40	8627.1	1958.2	2974.9	6553.0	40
42	8563.1	1922.0	2892.0	6442.5	42	42	8629.3	1959.5	2977.8	6556.9	42
44	8565.3	1923.2	2894.8	6446.3	44	44	8631.5	1960.7	2980.7	6560.7	44
46	8567.6	1924.5	2897.7	6450.1	46	46	8633.7	1962.0	2983.6	6564.6	46
48	8569.8	1925.7	2900.5	6453.9	48	48	8635.8	1963.2	2986.5	6568.4	48
50	8572.0	1927.0	2903.3	6457.6	50	50	8638.0	1964.5	2989.4	6572.3	50
52	8574.2	1928.2	2906.1	6461.4	52	52	8640.2	1965.8	2992.3	6576.2	52
54	8576.4	1929.4	2909.0	6465.2	54	54	8642.4	1967.0	2995.2	6580.0	54
56	8578.6	1930.7	2911.8	6469.0	56	56	8644.6	1968.3	2998.1	6583.9	56
58	8580.8	1931.9	2914.7	6472.8	58	58	8646.8	1969.5	3001.1	6587.7	58
60	8583.0	1933.2	2917.5	6476.6	60	60	8649.0	1970.8	3004.0	6591.6	60

98°.						99°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	8649.0	1970.8	3004.0	6591.6	0	0	8714.3	2008.7	3092.9	6709.0	0
2	8651.2	1972.0	3006.9	6595.5	2	2	8716.4	2009.9	3095.9	6712.9	2
4	8653.3	1973.3	3009.8	6599.4	4	4	8718.6	2011.2	3098.9	6716.9	4
6	8655.5	1974.6	3012.8	6603.2	6	6	8720.7	2012.5	3101.9	6720.8	6
8	8657.7	1975.8	3015.7	6607.1	8	8	8722.9	2013.7	3104.9	6724.8	8
10	8659.9	1977.1	3018.6	6611.0	10	10	8725.1	2015.0	3107.9	6728.8	10
12	8662.1	1978.3	3021.6	6614.9	12	12	8727.2	2016.3	3111.0	6732.7	12
14	8664.3	1979.6	3024.5	6618.8	14	14	8729.4	2017.5	3114.0	6736.7	14
16	8666.4	1980.9	3027.5	6622.7	16	16	8731.5	2018.8	3117.0	6740.7	16
18	8668.6	1982.1	3030.4	6626.6	18	18	8733.7	2020.1	3120.0	6744.6	18
20	8670.8	1983.4	3033.3	6630.5	20	20	8735.9	2021.4	3123.1	6748.6	20
22	8673.0	1984.6	3036.3	6634.4	22	22	8738.0	2022.6	3126.1	6752.6	22
24	8675.2	1985.9	3039.3	6638.3	24	24	8740.2	2023.9	3129.1	6756.6	24
26	8677.3	1987.2	3042.2	6642.2	26	26	8742.3	2025.2	3132.2	6760.6	26
28	8679.5	1988.4	3045.2	6646.1	28	28	8744.5	2026.4	3135.2	6764.6	28
30	8681.7	1989.7	3048.1	6650.0	30	30	8746.6	2027.7	3138.3	6768.6	30
32	8683.9	1991.0	3051.1	6653.9	32	32	8748.8	2029.0	3141.3	6772.6	32
34	8686.0	1992.2	3054.1	6657.8	34	34	8750.9	2030.3	3144.4	6776.6	34
36	8688.2	1993.5	3057.0	6661.7	36	36	8753.1	2031.5	3147.4	6780.6	36
38	8690.4	1994.7	3060.0	6665.7	38	38	8755.3	2032.8	3150.5	6784.6	38
40	8692.6	1996.0	3063.0	6669.6	40	40	8757.4	2034.1	3153.5	6788.6	40
42	8694.7	1997.3	3066.0	6673.5	42	42	8759.5	2035.4	3156.6	6792.6	42
44	8696.9	1998.5	3068.9	6677.4	44	44	8761.7	2036.6	3159.7	6796.6	44
46	8699.1	1999.8	3071.9	6681.4	46	46	8763.8	2037.9	3162.7	6800.6	46
48	8701.2	2001.1	3074.9	6685.3	48	48	8766.0	2039.2	3165.8	6804.6	48
50	8703.4	2002.3	3077.9	6689.2	50	50	8768.1	2040.5	3168.9	6808.6	50
52	8705.6	2003.6	3080.9	6693.2	52	52	8770.3	2041.7	3172.0	6812.6	52
54	8707.8	2004.9	3083.9	6697.1	54	54	8772.4	2043.0	3175.1	6816.7	54
56	8709.9	2006.1	3086.9	6701.1	56	56	8774.6	2044.3	3178.1	6820.7	56
58	8712.1	2007.4	3089.9	6705.2	58	58	8776.7	2045.6	3181.2	6824.7	58
60	8714.3	2008.7	3092.9	6709.0	60	60	8778.9	2046.8	3184.3	6828.8	60

	100°.						101°.				
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	8778.9	2046.8	3184.3	6828.8	0	0	8842.8	2085.3	3278.3	6951.0	0
2	8781.0	2048.1	3187.4	6832.8	2	2	8844.9	2086.6	3281.5	6955.2	2
4	8783.1	2049.4	3190.5	6836.8	4	4	8847.0	2087.8	3284.7	6959.3	4
6	8785.3	2050.7	3193.6	6840.9	6	6	8849.2	2089.1	3287.9	6963.4	6
8	8787.4	2051.9	3196.7	6844.9	8	8	8851.3	2090.4	3291.1	6967.6	8
10	8789.6	2053.2	3199.8	6849.0	10	10	8853.4	2091.7	3294.3	6971.7	10
12	8791.7	2054.5	3202.9	6853.0	12	12	8855.5	2093.0	3297.5	6975.8	12
14	8793.9	2055.8	3206.0	6857.1	14	14	8857.6	2094.3	3300.7	6980.0	14
16	8796.0	2057.1	3209.1	6861.1	16	16	8859.8	2095.6	3303.9	6984.1	16
18	8798.9	2058.3	3212.2	6865.2	18	18	8861.9	2096.9	3307.1	6988.2	18
20	8800.3	2059.6	3215.4	6869.2	20	20	8864.0	2098.2	3310.3	6992.4	20
22	8802.4	2060.9	3218.5	6873.3	22	22	8866.1	2099.4	3313.5	6996.6	22
24	8804.5	2062.2	3221.6	6877.4	24	24	8858.2	2100.7	3316.7	7000.7	24
26	8806.7	2063.5	3224.7	6881.4	26	26	8870.3	2102.0	3319.9	7004.9	26
28	8808.8	2064.7	3227.9	6885.5	28	28	8872.4	2103.3	3323.1	7009.0	28
30	8810.9	2066.0	3231.0	6889.6	30	30	8874.5	2104.6	3326.4	7013.2	30
32	8813.1	2067.3	3234.1	6893.7	32	32	8876.7	2105.9	3329.6	7017.3	32
34	8815.2	2068.6	3237.3	6897.8	34	34	8878.8	2107.2	3332.8	7021.5	34
36	8817.3	2069.9	3240.4	6901.8	36	36	8880.9	2108.5	3336.0	7025.7	36
38	8819.5	2071.1	3243.5	6905.9	38	38	8883.0	2109.8	3339.3	7029.9	38
40	8821.6	2072.4	3246.7	6910.0	40	40	8885.1	2111.1	3342.5	7034.0	40
42	8323.7	2073.7	3249.8	6914.1	42	42	8887.2	2112.4	3345.8	7038.2	42
44	8325.8	2075.0	3253.0	6918.2	44	44	8889.3	2113.6	3349.0	7042.4	44
46	8828.0	2076.3	3256.2	6922.3	46	46	8891.4	2114.9	3352.3	7046.6	46
48	8830.1	2077.6	3259.3	6926.4	48	48	8893.5	2116.2	3355.5	7050.8	48
50	8832.2	2078.9	3262.5	6930.5	50	50	8895.6	2117.5	3358.8	7055.0	50
52	8834.3	2080.1	3265.7	6934.6	52	52	8897.7	2118.8	3362.0	7059.2	52
54	8836.4	2081.4	3268.8	6938.7	54	54	8899.8	2120.1	3365.5	7063.4	54
56	8838.6	2082.7	3272.0	6942.8	56	56	8901.9	2121.4	3368.7	7067.6	56
58	8840.7	2084.0	3275.2	6946.9	58	58	8904.0	2122.7	3372.0	7071.8	58
60	8842.8	2085.3	3278.3	6951.0	60	60	8906.1	2124.0	3375.1	7076.0	60

	102°.					103°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	8906.1	2124.0	3375.1	7076.0	0	0	8968.7	2163.0	3474.6	7203.6	0
2	8908.2	2125.3	3378.3	7080.2	2	2	8970.8	2164.3	3478.0	7207.9	2
4	8910.3	2126.6	3381.6	7084.4	4	4	8972.9	2165.6	3481.4	7212.2	4
6	8912.4	2127.9	3384.9	7088.6	6	6	8974.9	2166.9	3484.7	7216.5	6
8	8914.5	2129.2	3388.2	7092.8	8	8	8977.0	2168.2	3488.1	7220.8	8
10	8916.6	2130.5	3391.5	7097.1	10	10	8979.1	2169.5	3491.5	7225.1	10
12	8918.7	2131.8	3394.7	7101.3	12	12	8981.1	2170.8	3494.9	7229.5	12
14	8920.8	2133.1	3398.0	7105.5	14	14	8983.2	2172.1	3498.3	7233.8	14
16	8922.9	2134.4	3401.3	7109.7	16	16	8985.3	2173.4	3501.6	7238.1	16
18	8925.0	2135.7	3404.6	7114.0	18	18	8987.3	2174.7	3505.3	7242.4	18
20	8927.0	2137.0	3407.9	7118.2	20	20	8989.4	2176.1	3508.4	7246.8	20
22	8929.1	2138.3	3411.2	7122.4	22	22	8991.5	2177.4	3511.8	7251.1	22
24	8931.2	2139.6	3414.5	7126.7	24	24	8993.5	2178.7	3515.2	7255.4	24
26	8933.3	2140.9	3417.9	7130.9	26	26	8995.6	2180.0	3518.7	7259.8	26
28	8935.4	2142.2	3421.2	7135.2	28	28	8997.7	2181.3	3522.1	7264.1	28
30	8937.5	2143.5	3424.5	7139.4	30	30	8999.7	2182.6	3525.5	7268.5	30
32	8939.6	2144.8	3427.8	7143.7	32	32	9001.8	2183.9	3528.9	7272.8	32
34	8941.6	2146.1	3431.1	7148.0	34	34	9003.9	2185.2	3532.3	7277.2	34
36	8943.7	2147.4	3434.5	7152.2	36	36	9005.9	2186.5	3535.7	7281.5	36
38	8945.8	2148.7	3437.8	7156.5	38	38	9008.0	2187.8	3539.2	7285.9	38
40	8947.9	2150.0	3441.1	7160.7	40	40	9010.0	2189.1	3542.6	7290.3	40
42	8950.0	2151.3	3444.4	7165.0	42	42	9012.1	2190.5	3546.0	7294.6	42
44	8952.1	2152.6	3447.8	7169.3	44	44	9014.2	2191.8	3549.5	7299.0	44
46	8954.1	2153.9	3451.1	7173.6	46	46	9016.2	2193.1	3552.9	7303.4	46
48	8956.2	2155.2	3454.5	7177.9	48	48	9018.3	2194.4	3556.3	7307.7	48
50	8958.3	2156.5	3457.8	7182.1	50	50	9020.3	2195.7	3559.8	7312.1	50
52	8960.4	2157.8	3461.2	7186.4	52	52	9022.4	2197.0	3563.2	7316.5	52
54	8962.5	2159.1	3464.5	7190.7	54	54	9024.5	2198.3	3566.7	7320.9	54
56	8964.5	2160.4	3467.9	7195.0	56	56	9026.5	2199.6	3570.2	7325.3	56
58	8966.6	2161.7	3471.2	7199.3	58	58	9028.6	2200.9	3573.6	7329.7	58
	8968.7	2163.0	3474.6	7203.6	60	60	9030.6	2202.3	3577.1	7334.1	60

104°.						105°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	9030.6	2202.3	3577.1	7334.1	0	0	9091.8	2241.8	3682.6	7467.5	0
2	9032.7	2203.6	3580.5	7338.5	2	2	9093.9	2243.1	3686.1	7472.0	2
4	9034.7	2204.9	3584.0	7342.9	4	4	9095.9	2244.4	3689.7	7476.5	4
6	9036.8	2206.2	3587.5	7347.3	6	6	9097.9	2245.8	3693.3	7481.0	6
8	9038.8	2207.5	3591.0	7351.7	8	8	9099.9	2247.1	3696.9	7485.5	8
10	9040.9	2208.8	3594.4	7356.1	10	10	9102.0	2248.4	3700.4	7490.0	10
12	9042.9	2210.2	3597.9	7360.5	12	12	9104.0	2249.7	3704.0	7494.5	12
14	9045.0	2211.5	3601.4	7364.9	14	14	9106.0	2251.1	3707.6	7499.1	14
16	9047.0	2212.8	3604.9	7369.4	16	16	9108.0	2252.4	3711.2	7503.6	16
18	9049.1	2214.1	3608.4	7373.8	18	18	9110.1	2253.7	3714.8	7508.1	18
20	9051.1	2215.4	3611.9	7378.2	20	20	9112.1	2255.0	3718.4	7512.6	20
22	9053.1	2216.7	3615.4	7382.6	22	22	9114.1	2256.4	3722.0	7517.2	22
24	9055.2	2218.0	3618.9	7387.1	24	24	9116.1	2257.7	3725.6	7521.7	24
26	9057.2	2219.4	3622.4	7391.5	26	26	9118.1	2259.0	3729.3	7526.3	26
28	9059.3	2220.7	3625.9	7396.0	28	28	9120.2	2260.3	3732.9	7530.8	28
30	9061.3	2222.0	3629.4	7400.4	30	30	9122.2	2261.7	3736.5	7535.3	30
32	9063.3	2223.3	3633.0	7404.8	32	32	9124.2	2263.0	3740.1	7539.9	32
34	9065.4	2224.6	3636.5	7409.3	34	34	9126.2	2264.3	3743.7	7544.4	34
36	9067.4	2226.0	3640.0	7413.8	36	36	9128.2	2265.7	3747.4	7549.0	36
38	9069.5	2227.3	3643.5	7418.2	38	38	9130.2	2267.0	3751.0	7553.6	38
40	9071.5	2228.6	3647.1	7422.7	40	40	9132.3	2268.3	3754.6	7558.1	40
42	9073.5	2229.9	3650.6	7427.1	42	42	9134.3	2269.6	3758.3	7562.7	42
44	9075.6	2231.2	3654.1	7431.6	44	44	9136.3	2271.0	3761.9	7567.3	44
46	9077.6	2232.6	3657.7	7436.1	46	46	9138.3	2272.3	3765.6	7571.8	46
48	9079.6	2233.9	3661.2	7440.6	48	48	9140.3	2273.6	3769.2	7576.4	48
50	9081.7	2235.2	3664.8	7445.0	50	50	9142.3	2275.0	3772.9	7581.0	50
52	9083.7	2236.5	3668.3	7449.5	52	52	9144.3	2276.3	3776.5	7585.6	52
54	9085.7	2237.8	3671.9	7454.0	54	54	9146.3	2277.6	3780.2	7590.2	54
56	9087.8	2239.2	3675.4	7458.5	56	56	9148.3	2278.9	3783.9	7594.8	56
58	9089.8	2240.5	3679.0	7463.0	58	58	9150.4	2280.3	3787.5	7599.4	58
60	9091.8	2241.8	3682.6	7467.5	60	60	9152.4	2281.6	3791.2	7604.0	60

106°.						107°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	9152.4	2281.6	3791.2	7604.0	0	0	9212.2	2321.7	3903.1	7743.7	0
2	9154.4	2282.9	3794.9	7608.6	2	2	9214.2	2323.0	3906.9	7748.4	2
4	9156.4	2284.3	3798.6	7613.2	4	4	9216.2	2324.4	3910.7	7753.1	4
6	9158.4	2285.6	3802.3	7617.8	6	6	9218.1	2325.7	3914.5	7757.8	6
8	9160.4	2286.9	3805.9	7622.4	8	8	9220.1	2327.0	3918.3	7762.5	8
10	9162.4	2288.3	3809.6	7627.0	10	10	9222.1	2328.4	3922.1	7767.3	10
12	9164.4	2289.6	3813.3	7631.7	12	12	9224.1	2329.7	3925.9	7772.0	12
14	9166.4	2290.9	3817.0	7636.3	14	14	9226.1	2331.1	3929.7	7776.7	14
16	9168.4	2292.3	3820.7	7640.9	16	16	9228.1	2332.4	3933.6	7781.5	16
18	9170.4	2293.6	3824.4	7645.5	18	18	9230.0	2333.7	3937.4	7786.2	18
20	9172.4	2294.9	3828.1	7650.2	20	20	9232.0	2335.1	3941.2	7791.0	20
22	9174.4	2296.3	3831.9	7654.8	22	22	9234.0	2336.4	3945.0	7795.7	22
24	9176.4	2297.6	3835.6	7659.5	24	24	9235.9	2337.8	3948.9	7800.5	24
26	9178.4	2298.9	3839.3	7664.1	26	26	9237.9	2339.1	3952.7	7805.2	26
28	9180.4	2300.3	3843.0	7668.8	28	28	9239.9	2340.5	3956.5	7810.0	28
30	9182.4	2301.6	3846.7	7673.4	30	30	9241.9	2341.8	3960.4	7814.7	30
32	9184.4	2302.9	3850.5	7678.1	32	32	9243.8	2343.1	3964.2	7819.5	32
34	9186.4	2304.3	3854.2	7682.7	34	34	9245.8	2344.5	3968.1	7824.3	34
36	9188.4	2305.6	3858.0	7687.4	36	36	9247.8	2345.8	3971.9	7829.1	36
38	9190.4	2306.9	3861.7	7692.1	38	38	9249.7	2347.2	3975.8	7833.8	38
40	9192.4	2308.3	3865.4	7696.7	40	40	9251.7	2348.5	3979.6	7838.6	40
42	9194.4	2309.6	3869.2	7701.4	42	42	9253.7	2349.9	3983.5	7843.4	42
44	9196.3	2311.0	3873.0	7706.1	44	44	9255.6	2351.2	3987.4	7848.2	44
46	9198.3	2312.3	3876.7	7710.8	46	46	9257.6	2352.6	3991.3	7853.0	46
48	9200.3	2313.6	3880.5	7715.5	48	48	9259.6	2353.9	3995.1	7857.8	48
50	9202.3	2315.0	3884.2	7720.1	50	50	9261.5	2355.3	3999.0	7862.6	50
52	9204.3	2316.3	3888.0	7724.8	52	52	9263.5	2356.6	4002.9	7867.4	52
54	9206.3	2317.7	3891.8	7729.5	54	54	9265.4	2358.0	4006.8	7872.2	54
56	9208.2	2319.0	3895.6	7734.2	56	56	9267.4	2359.3	4010.7	7877.0	56
58	9210.2	2320.3	3899.3	7739.0	58	58	9269.4	2360.7	4014.6	7881.9	58
60	9212.2	2321.7	3903.1	7743.7	60	60	9271.3	2362.0	4018.5	7886.7	60

	108°.					109°.					
Min.	**Chord.**	**Mid. Ord.**	**Ex. Sec.**	**A. D.**	**Min.**	**Min.**	**Chord.**	**Mid. Ord.**	**Ex. Sec.**	**A. D.**	**Min.**
0	9271.3	2362.0	4018.5	7886.7	0	0	9329.8	2402.6	4137.4	8033.2	0
2	9273.3	2363.3	4022.4	7891.5	2	2	9331.7	2403.9	4141.4	8038.1	2
4	9275.3	2364.7	4026.3	7896.3	4	4	9333.6	2405.1	4145.4	8043.1	4
6	9277.2	2366.0	4030.2	7901.2	6	6	9335.6	2406.6	4149.5	8048.0	6
8	9279.2	2367.4	4034.1	7906.0	8	8	9337.5	2408.0	4153.5	8053.0	8
10	9281.1	2368.7	4038.0	7910.8	10	10	9339.4	2409.4	4157.5	8057.9	10
12	9283.1	2370.1	4042.0	7915.7	12	12	9341.4	2410.7	4161.6	8062.9	12
14	9285.0	2371.4	4045.9	7920.5	14	14	9343.3	2412.1	4165.6	8067.9	14
16	9287.0	2372.8	4049.8	7925.4	16	16	9345.2	2413.4	4169.7	8072.8	16
18	9288.9	2374.1	4053.8	7930.3	18	18	9347.2	2414.8	4173.8	8077.8	18
20	9290.9	2375.5	4057.7	7935.1	20	20	9349.1	2416.2	4177.8	8082.8	20
22	9292.8	2376.8	4061.6	7940.0	22	22	9351.0	2417.5	4181.9	8087.8	22
24	9294.8	2378.2	4065.6	7944.8	24	24	9352.9	2418.9	4186.0	8092.8	24
26	9296.7	2379.5	4069.5	7949.7	26	26	9354.9	2420.2	4190.0	8097.8	26
28	9298.7	2380.9	4073.5	7954.6	28	28	9356.8	2421.6	4194.1	8102.8	28
30	9300.6	2382.3	4077.5	7959.5	30	30	9358.7	2423.0	4198.2	8107.8	30
32	9302.6	2383.6	4081.4	7964.4	32	32	9360.6	2424.3	4202.3	8112.8	32
34	9304.5	2385.0	4085.4	7969.3	34	34	9362.6	2425.7	4206.4	8117.8	34
36	9306.5	2386.3	4089.4	7974.1	36	36	9364.5	2427.0	4210.5	8122.8	36
38	9308.4	2387.7	4093.4	7979.0	38	38	9366.4	2428.4	4214.6	8127.8	38
40	9310.4	2389.0	4097.3	7983.9	40	40	9368.3	2429.8	4218.7	8132.8	40
42	9312.3	2390.4	4101.3	7988.8	42	42	9370.2	2431.1	4222.8	8137.9	42
44	9314.2	2391.7	4105.3	7993.8	44	44	9372.2	2432.5	4226.9	8142.9	44
46	9316.2	2393.1	4109.3	7998.7	46	46	9374.1	2433.9	4231.0	8147.9	46
48	9318.1	2394.4	4113.3	8003.6	48	48	9376.0	2435.2	4235.1	8153.0	48
50	9320.1	2395.8	4117.3	8008.5	50	50	9377.9	2436.6	4239.3	8158.0	50
52	9322.0	2397.2	4121.3	8013.4	52	52	9379.8	2438.0	4243.4	8163.1	52
54	9323.9	2398.5	4125.3	8018.4	54	54	9381.7	2439.3	4247.5	8168.1	54
56	9325.9	2399.9	4129.3	8023.3	56	56	9383.7	2440.7	4251.7	8173.2	56
58	9327.8	2401.2	4133.4	8028.2	58	58	9385.6	2442.1	4255.8	8178.2	58
60	9329.8	2402.6	4137.4	8033.2	60	60	9387.5	2443.4	4260.0	8183.3	60

110°.						111°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	9387.5	2443.4	4260.0	8183.3	0	0	9444.5	2484.5	4386.4	8337.2	0
2	9389.4	2444.8	4264.1	8188.4	2	2	9446.4	2485.9	4390.7	8342.4	2
4	9391.3	2446.1	4268.3	8193.4	4	4	9448.3	2487.2	4395.0	8347.6	4
6	9393.2	2447.5	4272.4	8198.5	6	6	9450.1	2488.6	4399.3	8352.8	6
8	9395.1	2448.9	4276.6	8203.6	8	8	9452.0	2490.0	4403.6	8358.0	8
10	9397.0	2450.2	4280.8	8208.7	10	10	9453.9	2491.4	4407.9	8363.2	10
12	9398.9	2451.6	4284.9	8213.8	12	12	9455.8	2492.7	4412.2	8368.5	12
14	9400.8	2453.0	4289.1	8218.9	14	14	9457.7	2494.1	4416.5	8373.7	14
16	9402.7	2454.3	4293.3	8224.0	16	16	9459.6	2495.5	4420.8	8378.9	16
18	9404.7	2455.7	4297.5	8229.1	18	18	9461.4	2496.9	4425.1	8384.1	18
20	9406.6	2457.1	4301.7	8234.2	20	20	9463.3	2498.2	4429.5	8389.4	20
22	9408.5	2458.4	4305.9	8239.3	22	22	9465.2	2499.6	4433.8	8394.6	22
24	9410.4	2459.8	4310.1	8244.4	24	24	9467.1	2501.0	4438.1	8399.9	24
26	9412.3	2461.2	4314.3	8249.5	26	26	9469.0	2502.4	4442.5	8405.1	26
28	9414.2	2462.6	4318.5	8254.6	28	28	9470.8	2503.8	4446.8	8410.4	28
30	9416.1	2463.9	4322.7	8259.8	30	30	9472.7	2505.1	4451.2	8415.6	30
32	9418.0	2465.3	4326.9	8264.9	32	32	9474.6	2506.5	4455.5	8420.9	32
34	9419.9	2466.7	4331.1	8270.0	34	34	9476.5	2507.9	4459.9	8426.2	34
36	9421.8	2468.0	4335.4	8275.2	36	36	9478.3	2509.3	4464.2	8431.4	36
38	9423.7	2469.4	4339.6	8280.3	38	38	9480.2	2510.6	4468.6	8436.7	38
40	9425.6	2470.8	4343.8	8285.5	40	40	9482.1	2512.0	4473.0	8442.0	40
42	9427.5	2472.1	4348.1	8290.6	42	42	9484.0	2513.4	4477.3	8447.3	42
44	9429.3	2473.5	4352.3	8295.8	44	44	9485.8	2514.8	4481.7	8452.6	44
46	9431.2	2474.9	4356.6	8300.9	46	46	9487.7	2516.2	4486.1	8457.9	46
48	9433.1	2476.3	4360.8	8306.1	48	48	9489.6	2517.5	4490.5	8463.2	48
50	9435.0	2477.6	4365.1	8311.3	50	50	9491.4	2518.9	4494.9	8468.5	50
52	9436.9	2479.0	4369.3	8316.5	52	52	9493.3	2520.3	4499.3	8473.8	52
54	9438.8	2480.4	4373.6	8321.6	54	54	9495.2	2521.7	4503.7	8479.1	54
56	9440.7	2481.7	4377.9	8326.8	56	56	9497.0	2523.1	4508.1	8484.4	56
58	9442.6	2483.1	4382.2	8332.0	58	58	9498.9	2524.5	4512.5	8489.7	58
60	9444.5	2484.5	4386.4	8337.2	60	60	9500.8	2525.8	4516.9	8495.1	60

	112°.					113°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	9500.8	2525.8	4516.9	8495.1	0	0	9556.3	2567.4	4651.6	8657.1	0
2	9502.6	2527.2	4521.4	8500.4	2	2	9558.2	2568.8	4656.2	8662.6	2
4	9504.5	2528.6	4525.8	8505.8	4	4	9560.0	2570.2	4660.8	8668.0	4
6	9506.4	2530.0	4530.2	8511.1	6	6	9561.8	2571.6	4665.4	8673.5	6
8	9508.2	2531.4	4534.6	8516.4	8	8	9563.7	2573.0	4669.9	8679.0	8
10	9510.1	2532.7	4539.1	8521.8	10	10	9565.5	2574.4	4674.5	8684.5	10
12	9511.9	2534.1	4543.5	8527.1	12	12	9567.4	2575.8	4679.1	8690.0	12
14	9513.8	2535.5	4548.0	8532.5	14	14	9569.2	2577.1	4683.7	8695.5	14
16	9515.7	2536.9	4552.4	8537.9	16	16	9571.0	2578.5	4688.3	8701.0	16
18	9517.5	2538.3	4556.9	8543.2	18	18	9572.9	2579.9	4692.9	8706.5	18
20	9519.4	2539.7	4561.3	8548.6	20	20	9574.7	2581.3	4697.5	8712.0	20
22	9521.2	2541.0	4565.8	8554.0	22	22	9576.5	2582.7	4702.1	8717.6	22
24	9523.1	2542.4	4570.3	8559.4	24	24	9578.4	2584.1	4706.8	8723.1	24
26	9524.9	2543.8	4574.8	8564.8	26	26	9580.2	2585.5	4711.4	8728.6	26
28	9526.8	2545.2	4579.3	8570.2	28	28	9582.0	2586.9	4716.0	8734.2	28
30	9528.6	2546.6	4583.7	8575.6	30	30	9583.8	2588.3	4720.6	8739.7	30
32	9530.5	2548.0	4588.2	8581.0	32	32	9585.7	2589.7	4725.3	8745.3	32
34	9532.3	2549.4	4592.7	8586.4	34	34	9587.5	2591.1	4729.9	8750.8	34
36	9534.2	2550.7	4597.2	8591.8	36	36	9589.3	2592.5	4734.6	8756.4	36
38	9536.0	2552.1	4601.7	8597.2	38	38	9591.1	2593.9	4739.2	8761.9	38
40	9537.9	2553.5	4606.2	8602.6	40	40	9593.0	2595.3	4743.9	8767.5	40
42	9539.7	2554.9	4610.8	8608.0	42	42	9594.8	2596.7	4748.5	8773.1	42
44	9541.6	2556.3	4615.3	8613.5	44	44	9596.6	2598.1	4753.2	8778.6	44
46	9543.4	2557.7	4619.8	8618.9	46	46	9598.4	2599.4	4757.9	8784.2	46
48	9545.3	2559.1	4624.3	8624.3	48	48	9600.3	2600.8	4762.6	8789.8	48
50	9547.1	2560.5	4628.9	8629.8	50	50	9602.1	2602.2	4767.2	8795.4	50
52	9549.0	2561.8	4633.4	8635.2	52	52	9603.9	2603.6	4771.9	8801.0	52
54	9550.8	2563.2	4638.0	8640.7	54	54	9605.7	2605.0	4776.6	8806.6	54
56	9552.6	2564.6	4642.5	8646.2	56	56	9607.5	2606.4	4781.3	8812.2	56
58	9554.5	2566.0	4647.1	8651.6	58	58	9609.4	2607.8	4786.0	8817.8	58
60	9556.3	2567.4	4651.6	8657.1	60	60	9611.2	2609.2	4790.7	8823.4	60

114°.						115°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	9611.2	2609.2	4790.7	8823.4	0	0	9665.3	2651.3	4934.4	8994.3	0
2	9613.0	2610.6	4795.5	8829.1	2	2	9667.1	2652.7	4939.3	9000.1	2
4	9614.8	2612.0	4800.2	8834.7	4	4	9668.8	2654.1	4944.2	9005.9	4
6	9616.6	2613.4	4804.9	8840.3	6	6	9670.6	2655.5	4949.1	9011.6	6
8	9618.4	2614.8	4809.6	8846.0	8	8	9672.4	2656.9	4954.0	9017.4	8
10	9620.2	2616.2	4814.4	8851.6	10	10	9674.2	2658.3	4958.9	9023.2	10
12	9622.0	2617.6	4819.1	8857.2	12	12	9676.0	2659.7	4963.8	9029.0	12
14	9623.8	2619.0	4823.9	8862.9	14	14	9677.8	2661.1	4968.7	9034.8	14
16	9625.7	2620.4	4828.6	8868.5	16	16	9679.6	2662.5	4973.6	9040.7	16
18	9627.5	2621.8	4833.4	8874.2	18	18	9681.4	2663.9	4978.5	9046.5	18
20	9629.3	2623.2	4838.1	8879.9	20	20	9683.1	2665.4	4983.4	9052.3	20
22	9631.1	2624.6	4842.9	8885.5	22	22	9684.9	2666.8	4988.3	9058.1	22
24	9632.9	2626.0	4847.7	8891.2	24	24	9686.7	2668.2	4993.3	9064.0	24
26	9634.7	2627.4	4852.4	8896.9	26	26	9688.5	2669.6	4998.2	9069.8	26
28	9636.5	2628.8	4857.2	8902.6	28	28	9690.3	2671.0	5003.2	9075.7	28
30	9638.3	2630.2	4862.0	8908.3	30	30	9692.0	2672.4	5008.1	9081.5	30
32	9640.1	2631.6	4866.8	8914.0	32	32	9693.8	2673.8	5013.1	9087.4	32
34	9641.9	2633.0	4871.6	8919.7	34	34	9695.6	2675.2	5018.0	9093.2	34
36	9643.7	2634.4	4876.4	8925.4	36	36	9697.4	2676.6	5023.0	9099.1	36
38	9645.5	2635.8	4881.2	8931.1	38	38	9699.1	2678.0	5028.0	9105.0	38
40	9647.3	2637.2	4886.0	8936.8	40	40	9700.9	2679.5	5032.9	9110.8	40
42	9649.1	2638.6	4890.9	8942.6	42	42	9702.7	2680.9	5037.9	9116.7	42
44	9650.9	2640.0	4895.7	8948.3	44	44	9704.5	2682.3	5042.9	9122.6	44
46	9652.7	2641.4	4900.5	8954.0	46	46	9706.2	2683.7	5047.9	9128.5	46
48	9654.5	2642.9	4905.3	8959.8	48	48	9708.0	2685.1	5052.9	9134.4	48
50	9656.3	2644.3	4910.2	8965.5	50	50	9709.8	2686.5	5057.9	9140.3	50
52	9658.1	2645.7	4915.0	8971.3	52	52	9711.6	2687.9	5062.9	9146.2	52
	9659.9	2647.1	4919.9	8977.0	54	54	9713.3	2689.3	5067.9	9152.1	54
	9661.7	2648.5	4924.7	8982.8	56	56	9715.1	2690.7	5072.9	9158.1	56
	9663.5	2649.9	4929.6	8988.5	58	58	9716.9	2692.2	5078.0	9164.0	58
	9665.3	2651.3	4934.4	8994.3	60	60	9718.6	2693.6	5083.0	9169.9	60

116°.						117°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	9718.6	2693.6	5083.0	9169.9	0	0	9771.3	2736.1	5236.6	9350.5	0
2	9720.4	2695.0	5088.0	9175.9	2	2	9773.0	2737.5	5241.8	9356.6	2
4	9722.2	2696.4	5093.1	9181.8	4	4	9774.7	2738.9	5247.0	9362.7	4
6	9723.9	2697.8	5098.1	9188.8	6	6	9776.5	2740.4	5252.2	9368.9	6
8	9725.7	2699.2	5103.2	9193.7	8	8	9778.2	2741.8	5257.4	9375.0	8
10	9727.4	2700.6	5108.2	9199.7	10	10	9779.9	2743.2	5262.6	9381.1	10
12	9729.2	2702.1	5113.3	9205.6	12	12	9781.7	2744.6	5267.9	9387.3	12
14	9731.0	2703.5	5118.4	9211.6	14	14	9783.4	2746.0	5273.1	9393.4	14
16	9732.7	2704.9	5123.4	9217.6	16	16	9785.2	2747.5	5278.4	9399.5	16
18	9734.5	2706.3	5128.5	9223.6	18	18	9786.9	2748.9	5283.6	9405.7	18
20	9736.3	2707.7	5133.6	9229.6	20	20	9788.6	2750.3	5288.9	9411.9	20
22	9738.0	2709.1	5138.7	9235.5	22	22	9790.4	2751.7	5294.2	9418.0	22
24	9739.8	2710.6	5143.8	9241.5	24	24	9792.1	2753.2	5299.5	9424.2	24
26	9741.5	2712.0	5148.9	9247.6	26	26	9793.8	2754.6	5304.7	9430.4	26
28	9743.3	2713.4	5154.0	9253.6	28	28	9795.6	2756.0	5310.0	9436.6	28
30	9745.0	2714.8	5159.1	9259.6	30	30	9797.3	2757.4	5315.3	9442.8	30
32	9746.8	2716.2	5164.2	9265.6	32	32	9799.0	2758.9	5320.6	9449.0	32
34	9748.5	2717.6	5169.4	9271.6	34	34	9800.7	2760.3	5325.9	9455.2	34
36	9750.3	2719.1	5174.5	9277.7	36	36	9802.5	2761.7	5331.2	9461.4	36
38	9752.0	2720.5	5179.7	9283.7	38	38	9804.2	2763.1	5336.5	9467.6	38
40	9753.8	2721.9	5184.8	9289.8	40	40	9805.9	2764.6	5341.8	9473.8	40
42	9755.6	2723.3	5190.0	9295.8	42	42	9807.7	2766.0	5347.2	9480.0	42
44	9757.3	2724.7	5195.1	9301.9	44	44	9809.4	2767.4	5352.5	9486.3	44
46	9759.0	2726.2	5200.3	9307.9	46	46	9811.1	2768.8	5357.9	9492.5	46
48	9760.8	2727.6	5205.4	9314.0	48	48	9812.8	2770.3	5363.2	9498.7	48
50	9762.5	2729.0	5210.6	9320.1	50	50	9814.5	2771.7	5368.5	9505.0	50
52	9764.3	2730.4	5215.8	9326.1	52	52	9816.3	2773.1	5373.9	9511.2	52
54	9766.0	2731.8	5221.0	9332.2	54	54	9818.0	2774.6	5379.3	9517.5	54
56	9767.8	2733.3	5226.2	9338.3	56	56	9819.7	2776.0	5384.7	9523.8	56
58	9769.5	2734.7	5231.4	9344.4	58	58	9821.4	2777.4	5390.0	9530.0	58
60	9771.3	2736.1	5236.6	9350.5	60	60	9823.1	2778.8	5395.4	9536.3	60

118°.						119°.					
MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.	MIN.	CHORD.	MID. ORD.	EX. SEC.	A. D.	MIN.
0	9823.1	2778.8	5395.4	9536.3	0	0	9874.3	2821.8	5559.8	9727.6	0
2	9824.9	2780.3	5400.8	9542.6	2	2	9876.0	2823.3	5565.4	9734.1	2
4	9826.6	2781.7	5406.2	9548.9	4	4	9877.7	2824.7	5571.0	9740.6	4
6	9828.3	2783.1	5411.6	9555.2	6	6	9879.3	2826.1	5576.6	9747.1	6
8	9830.0	2784.6	5417.0	9561.5	8	8	9881.0	2827.6	5582.2	9753.6	8
10	9831.7	2786.0	5422.4	9567.8	10	10	9882.7	2829.0	5587.8	9760.1	10
12	9833.4	2787.4	5427.8	9574.1	12	12	9884.4	2830.4	5593.4	9766.6	12
14	9835.1	2788.8	5433.3	9580.5	14	14	9886.1	2831.9	5599.0	9773.1	14
16	9836.8	2790.3	5438.7	9586.8	16	16	9887.8	2833.3	5604.6	9779.6	16
18	9838.6	2791.7	5444.1	9593.1	18	18	9889.5	2834.7	5610.3	9786.1	18
20	9840.3	2793.1	5449.6	9599.5	20	20	9891.2	2836.2	5615.9	9792.6	20
22	9842.0	2794.6	5455.0	9605.8	22	22	9892.8	2837.6	5621.5	9799.2	22
24	9843.7	2796.0	5460.5	9612.2	24	24	9894.5	2839.1	5627.2	9805.7	24
26	9845.4	2797.4	5466.0	9618.5	26	26	9896.2	2840.5	5632.8	9812.3	26
28	9847.1	2798.9	5471.4	9624.9	28	28	9897.9	2841.9	5638.5	9818.8	28
30	9848.8	2800.3	5476.9	9631.3	30	30	9899.5	2843.4	5644.2	9825.4	30
32	9850.5	2801.7	5482.4	9637.6	32	32	9901.2	2844.8	5649.8	9832.0	32
34	9852.2	2803.2	5487.9	9644.0	34	34	9902.9	2846.3	5655.5	9838.6	34
36	9853.9	2804.6	5493.4	9650.4	36	36	9904.6	2847.7	5661.2	9845.1	36
38	9855.6	2806.0	5498.9	9656.8	38	38	9906.3	2849.1	5666.9	9851.7	38
40	9857.3	2807.5	5504.4	9663.2	40	40	9907.9	2850.6	5672.6	9858.3	40
42	9859.0	2808.9	5509.9	9669.6	42	42	9909.6	2852.2	5678.3	9864.9	42
44	9860.7	2810.3	5515.4	9676.1	44	44	9911.3	2853.5	5684.1	9871.5	44
46	9862.4	2811.8	5520.9	9682.5	46	46	9913.0	2854.9	5689.8	9878.2	46
48	9864.1	2813.2	5526.5	9688.9	48	48	9914.6	2856.3	5695.5	9884.8	48
50	9865.8	2814.6	5532.0	9695.3	50	50	9916.3	2857.8	5701.2	9891.4	50
52	9867.5	2816.1	5537.6	9701.8	52	52	9918.0	2859.2	5707.0	9898.0	52
54	9869.2	2817.5	5543.1	9708.2	54	54	9919.6	2860.7	5712.7	9904.7	54
56	9870.9	2818.9	5548.7	9714.7	56	56	9921.3	2862.1	5718.5	9911.3	56
58	9872.6	2820.4	5554.2	9721.2	58	58	9923.0	2863.6	5724.2	9918.0	58
60	9874.3	2821.8	5559.8	9727.6	60	60	9924.7	2865.0	5730.0	9924.7	60

TABLE XVII.

RISE PER MILE OF VARIOUS GRADES.

TABLE XVII.—RISE PER MILE OF VARIOUS GRADES.

Rise per Cent.	Feet per Mile.	Rise per Cent.	Feet per Mile.	Rise per Cent.	Feet per Mile.	Rise per Cent.	Feet per Mile.
.01	.528	.61	32.208	1.21	63.888	1.81	95.568
.02	1.056	.62	32.736	1.22	64.416	1.82	96.096
.03	1.584	.63	33.264	1.23	64.944	1.83	96.624
.04	2.112	.64	33.792	1.24	65.472	1.84	97.152
.05	2.640	.65	34.320	1.25	66.000	1.85	97.680
.06	3.168	.66	34.848	1.26	66.528	1.86	98.208
.07	3.696	.67	35.376	1.27	67.056	1.87	98.736
.08	4.224	.68	35.904	1.28	67.584	1.88	99.264
.09	4.752	.69	36.432	1.29	68.112	1.89	99.792
.10	5.280	.70	36.960	1.30	68.640	1.90	100.320
.11	5.808	.71	37.488	1.31	69.168	1.91	100.848
.12	6.336	.72	38.016	1.32	69.696	1.92	101.376
.13	6.864	.73	38.544	1.33	70.224	1.93	101.904
.14	7.392	.74	39.072	1.34	70.752	1.94	102.432
.15	7.920	.75	39.600	1.35	71.280	1.95	102.960
.16	8.448	.76	40.128	1.36	71.808	1.96	103.488
.17	8.976	.77	40.656	1.37	72.336	1.97	104.016
.18	9.504	.78	41.184	1.38	72.864	1.98	104.544
.19	10.032	.79	41.712	1.39	73.392	1.99	105.072
.20	10.560	.80	42.240	1.40	73.920	2.00	105.600
.21	11.088	.81	42.768	1.41	74.448	2.10	110.880
.22	11.616	.82	43.296	1.42	74.976	2.20	116.160
.23	12.144	.83	43.824	1.43	75.504	2.30	121.440
.24	12.672	.84	44.352	1.44	76.032	2.40	126.720
.25	13.200	.85	44.880	1.45	76.560	2.50	132.000
.26	13.728	.86	45.408	1.46	77.088	2.60	137.280
.27	14.256	.87	45.936	1.47	77.616	2.70	142.560
.28	14.784	.88	46.464	1.48	78.144	2.80	147.840
.29	15.312	.89	46.992	1.49	78.672	2.90	153.120
.30	15.840	.90	47.520	1.50	79.200	3.00	158.400
.31	16.368	.91	48.048	1.51	79.728	3.10	163.680
.32	16.896	.92	48.576	1.52	80.256	3.20	168.960
.33	17.424	.93	49.104	1.53	80.784	3.30	174.240
.34	17.952	.94	49.632	1.54	81.312	3.40	179.520
.35	18.480	.95	50.160	1.55	81.840	3.50	184.800
.36	19.008	.96	50.688	1.56	82.368	3.60	190.080
.37	19.536	.97	51.216	1.57	82.896	3.70	195.360
.38	20.064	.98	51.744	1.58	83.424	3.80	200.640
.39	20.592	.99	52.272	1.59	83.952	3.90	205.920
.40	21.120	1.00	52.800	1.60	84.480	4.00	211.200
.41	21.648	1.01	53.328	1.61	85.008	4.10	216.480
.42	22.176	1.02	53.856	1.62	85.536	4.20	221.760
.43	22.704	1.03	54.384	1.63	86.064	4.30	227.040
.44	23.232	1.04	54.912	1.64	86.592	4.40	232.320
.45	23.760	1.05	55.440	1.65	87.120	4.50	237.600
.46	24.288	1.06	55.968	1.66	87.648	4.60	242.880
.47	24.816	1.07	56.496	1.67	88.176	4.70	248.160
.48	25.344	1.08	57.024	1.68	88.704	4.80	253.440
.49	25.872	1.09	57.552	1.69	89.232	4.90	258.720
.50	26.400	1.10	58.080	1.70	89.760	5.00	264.000
.51	26.928	1.11	58.608	1.71	90.288	5.10	269.280
.52	27.456	1.12	59.136	1.72	90.816	5.20	274.560
.53	27.984	1.13	59.664	1.73	91.344	5.30	279.840
.54	28.512	1.14	60.192	1.74	91.872	5.40	285.120
.55	29.040	1.15	60.720	1.75	92.400	5.50	290.400
.56	29.568	1.16	61.248	1.76	92.928	5.60	295.680
.57	30.096	1.17	61.776	1.77	93.456	5.70	300.960
.58	30.624	1.18	62.304	1.78	93.984	5.80	306.240
.59	31.152	1.19	62.832	1.79	94.512	5.90	311.520
.60	31.680	1.20	63.360	1.80	95.040	6.00	316.800

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